F

2.3.3

Notes by
E. Wardell-Yerburgh's
grand-father
Henry Potts of
Watergate House
Chester.

F

1 E.

2 F

Iſt. Part of the Courſe.

Metals and Minerals.

Art of Mining. Strata. Airing Mines.

Iron. Caſting and boring Cannon. Malleable Iron. Rolling and Slitting. Wire drawing. Steel. Modern Diſcoveries in Chemiſtry, relative to Steel and Iron.

Lead. Red and white Lead. Rolling Lead.

Tin.

Copper. Arts of engraving and etching. Mezzotinto. Aquatinta.

Silver. Separating it from Lead. Plating. Stamping.

Gold. Beating. Coining.

Mixed metals. Solders. Printer's types. Pewter. Cock metal.

Braſs. Engines for turning, cutting teeth in wheels, cutting ſcrews, boring, &c.

Coal. Bitumen, Mineral Tar.

Marble. Sawing, Sweeping and Poliſhing.

Lime.

Clay. Pottery. Modelling.

Flint. Glaſs. Grinding Optical Glaſſes.

Nitre. Sulphur. Gunpowder, granulating and glazing.

Salt. Rock Salt. Salt Springs. Sea Salt. Epſom and Glauber Salt from Seawater.

During this part of the Lectures will be introduced Experiments on the moving Force of Engines carried by Wind, Water and Steam, and alſo an Explanation of Wheels and other Parts of Mill-work.

IId. Part

IId. Part of the Courſe.

Animal and Vegetable Subſtances.

Fiſheries. Whale. Cod. Herring. Salmon.

Oil. Animal. Vegetable.

Leather.

Sugar. Raw. Refined.

Arts relative to Clothing.

Flax and Hemp.

Cotton. Carding, Drawing and Spinning.

Silk. Mode of obtaining it. Twiſting.

Wool. Long. Short. Combing. Weaving. Dreſſing Cloth. Frizing. Fulling.

Felting Wool. Beaver.

Bleaching and Dyeing. Printing Cotton and Linen.

Paper. Grinding. Molding. Sizing.

IIId. Part of the Courſe.

Arts relative to Commerce and Navigation.

Navigable Rivers and Canals. Harbours and Docks.

Experiments relative to the Stability of Floating Bodies.

Reſiſtance of Bodies moving in Fluids.

Models of Ships.

Method of launching Ships.

The Application of Models to large Works.

1

Farish's Lectures

on

the Manufactures

read at

The Botanic Gardens

Cambridge

Feb. 25. 1795 —

attended by [illegible]

Taken at the time

By — Henry Potts —

(of [illegible])

MSS
1696 B
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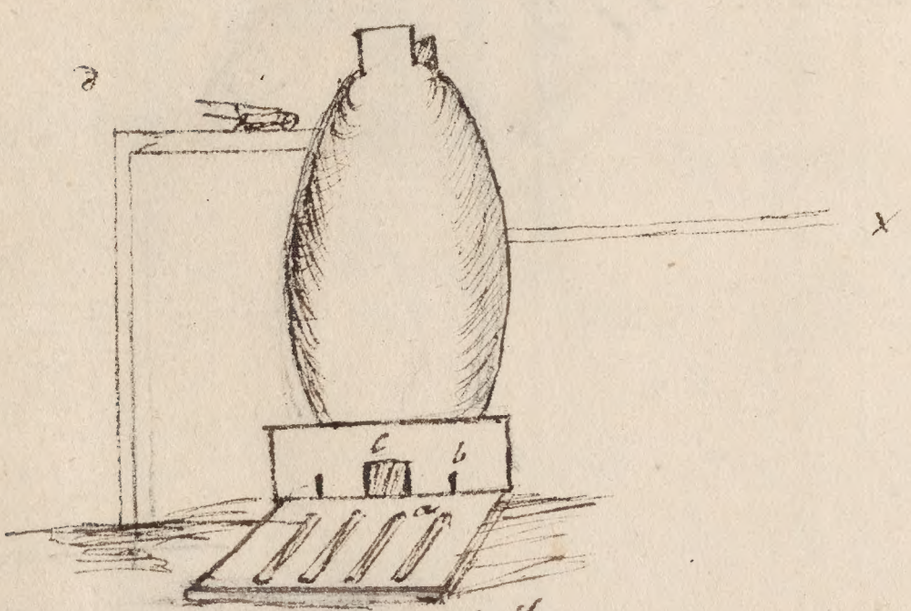
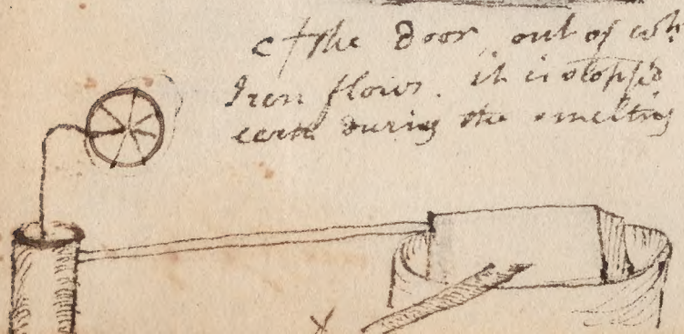
Iron is beaten also by a hammer to expell the he-
terogeneous particles —

Furnace —



c / the door, out of wh. the Iron flows. it is stopped with earth during the smelting —

a - pigs / b / to let out go dro
d / the floor from which it is filled with fuel —



Yorkshire manufacturers can afford to purchase wool in ye west of England manufacture it, and afterwards on carrying it back into the west undersell the manufacturers there. This is owing to the different manner in which the manufactures are carried on in the two Countries. In the west the wealthy Traders form a monopoly & employ the poorer people as workmen. In Yorkshire each individual is independent, & upon his own bottom & the woollen Halls always afford a ready market for their goods.

Iron

after it is dug out is roasted & then smelted & for that purpose put into a furnace —

the furnace is supplied with air by a water Machine wh raises air from a receiver, wh is conveyed thro' a pipe with ye necessary valves into an inverted reservoir in a quantity of water, the air thus condensed is driven by ye force of ye water pressing it up thro' a pipe into the furnace. The Iron is about 24 hours in melting. The furnace is filled with limestone and fuel & they keep continually supplying it.

Coke at first

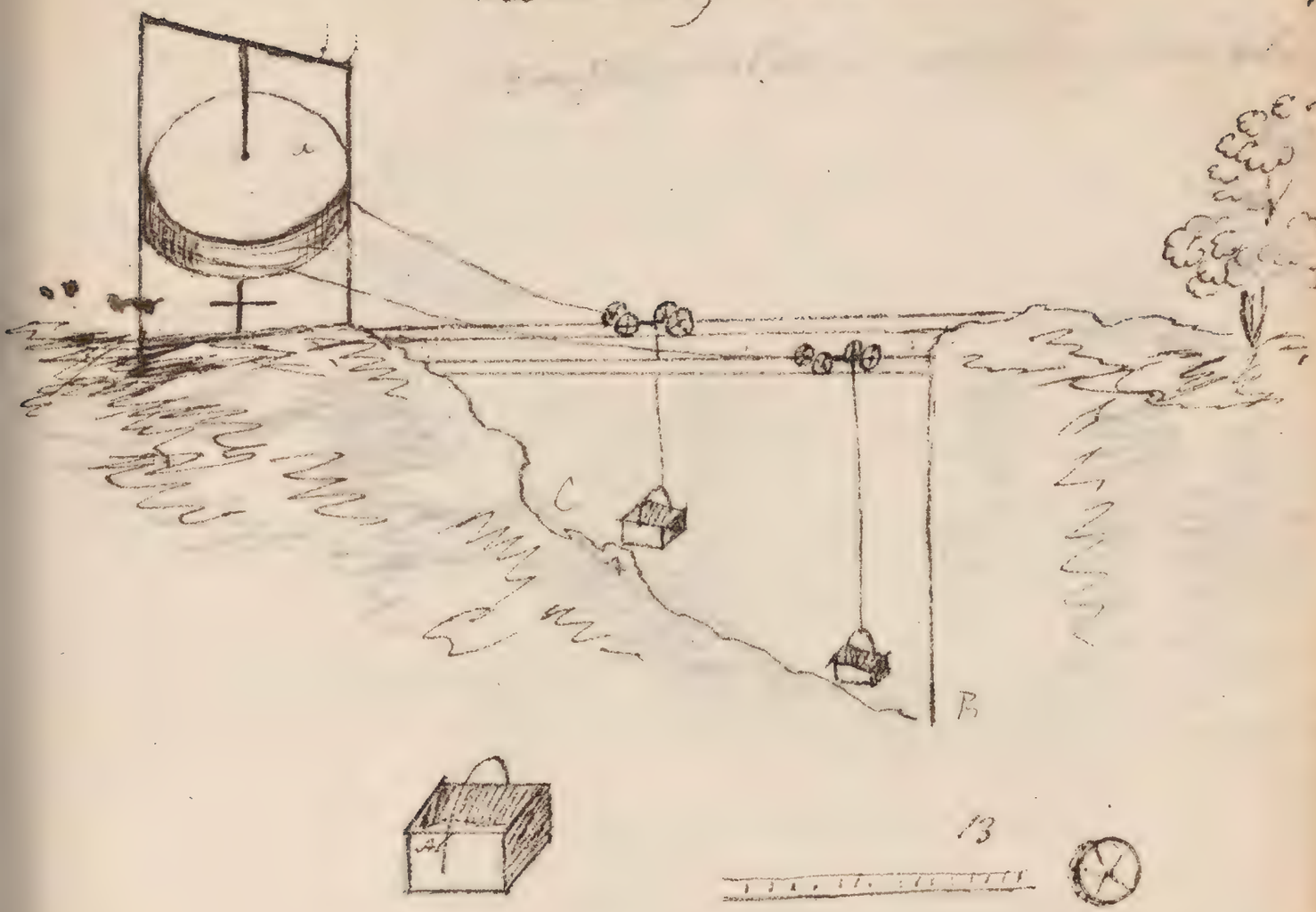
Iron ore lies in lumps. the best english ore is brought from furness. it is much softer than any other. The swedish Iron is generally used in making steel. American Iron much used. It is sometimes in the mines laid open to the day, but if [illegible] deep it is obtained as other minerals. If they want to level the earth they use a machine of this sort.

The first operation in Iron is roasting in order to disengage the sulphur (wt make it unmalleable) & to open the pores, exposed in large heaps with ashes & set on fire. after this it is exposed to a gradual heat in the furnace, for as the ore sinks it becomes hotter. It is necessary to resmelt the ore sometimes in making cannon. for this purpose it is put into a furnace. The grate is in A, & the heat passes through the aperture C into D, & the light air ascending thro' the chimney, the furnace acts without bellows on account of the great draught.

Iron is at first very brittle & not malleable, to render it so they put it again into the furnace & alternately cool & heat it.

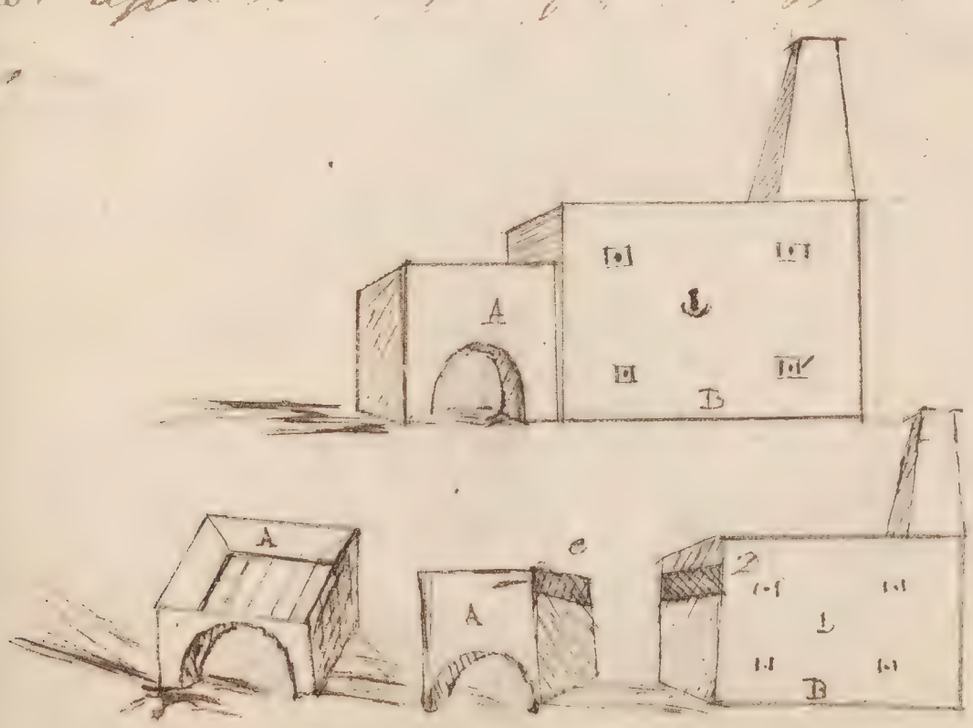
DSI

Levelling Machine



A. Box hung below ye centre of gravity so that when the peg is taken out it empties itself —

B. The waggon way with spikes in it which fit the holes in the wheel & prevent it slipping — The cord winds upon the axle of the waggon & so the Box rises —



It is then rolled ~~by~~ between two cylinders work'd by water — Wilkinson makes his cylinders pass it thro' & then repass it.

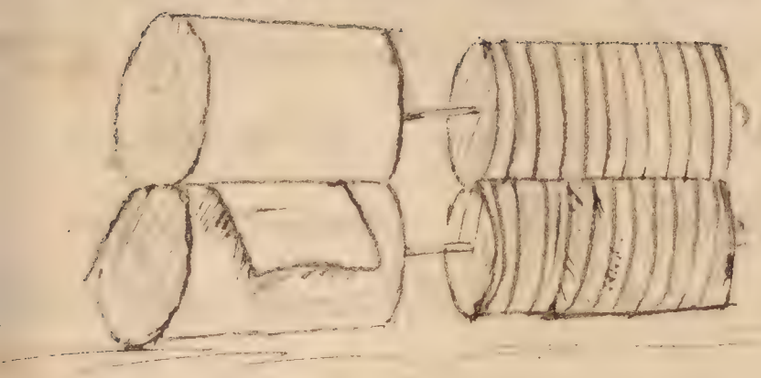
In turning Cannon it is necessary that the cannon should move round that the bore may be true. because it corrects itself If the bore be not true the motion would immediately snap the borer — The cannon is finished by turning i.e. it is cut with instruments during the time of its being bored — a small borer is first used & then a larger &c

In order to convey a great weight of melted Iron to a distance they use a crane —

To form Bells & Cylinders they make use of this machine; they put a model & coat it over & form the coating by the machine then put another model over & coat that over take away the last model & fill the empty space with metal —

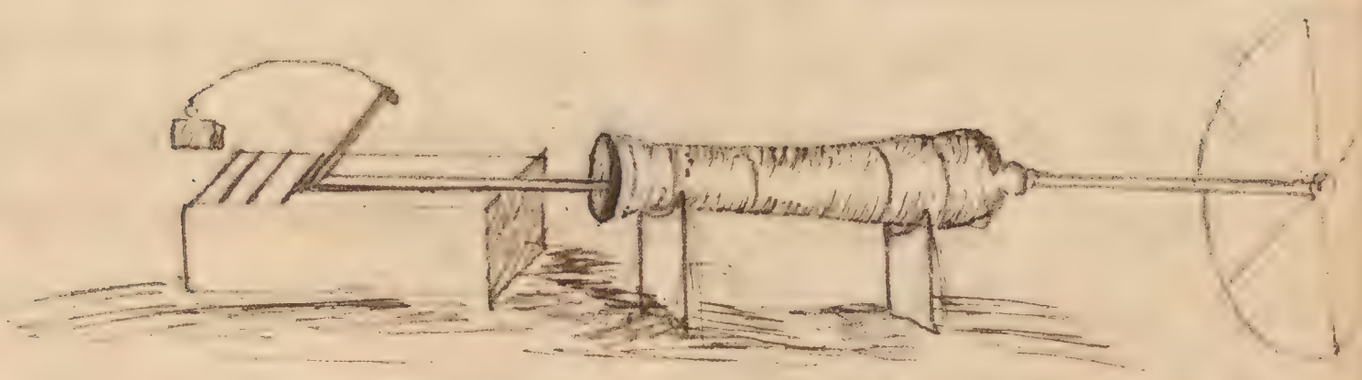
~~Iron made into steel by putting it in a furnace ~~ ~~blis with charcoal & heating it & rooting it gradually. It is apt to be blistered these blisters are taken off by putting it in a furnace with charcoal~~

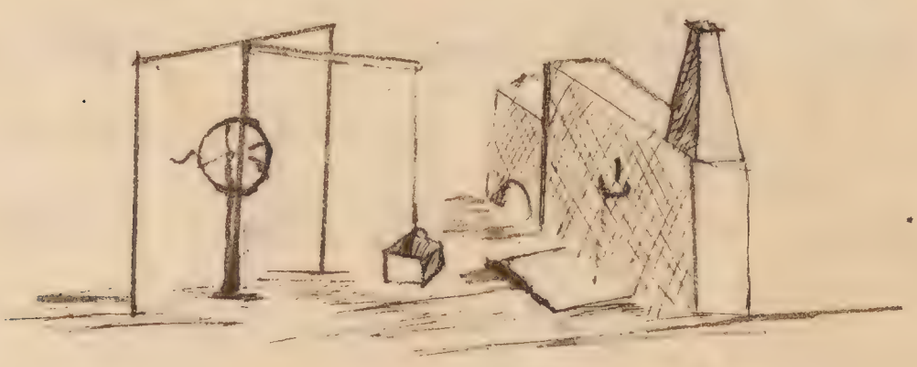
Roller Roller

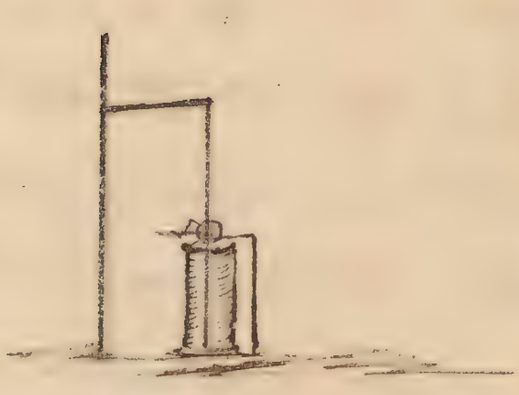


Water

Water





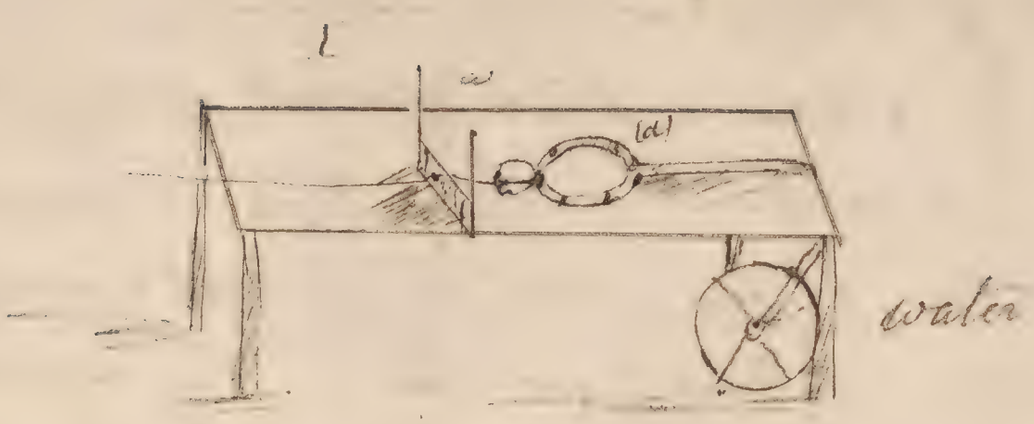


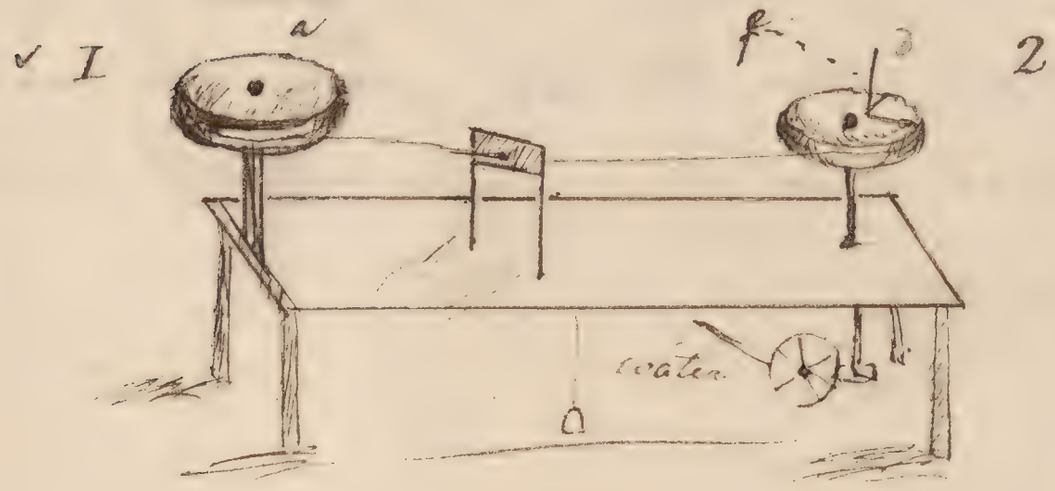
Iron is converted into steel by cementation. It is bedded in charcoal in a crucible & kept in a red heat for some hours. 6 to 10 It gains a small addition of weight $\frac{1}{200}$. Much more brittle & fusible than before. It will not weld. Harder than Iron. It is apt to be blistered. This is removed by forging (tilting hammer). This alteration in the metal is owing to the inflammable principle of the charcoal. It possesses a greater ductility, fusibility, flexibility & softness (till tempered) than Iron. It may be hardened by being plung'd when ignited into cold water, & softened by being cooled gradually. It is tempered by being slowly heated. The following colours appear in succession. yellowish white, yellow, gold purple, violet, deep blue, yellowish white. Steel not prop. for edged tools of too hard on acc.t of its brittleness, nor when too soft. The blue is used for springs — To make files they soften the steel & cut the teeth ~~by~~ with a chisel & mallet these are regular on account of the rising of the steel after each stroke. It is then hardened. It will cut Iron — very magnetic. In order to temper steel it is plung'd into such Oil wine, sal ammoniac &c — The colours are owing to calcination — The particles in the different stages are of diff. sizes & acquire (Newton) diff. colors.

After the Iron has been rolled & slit, they draw it out into wire — by this operation it acquires a great degree of hardness, which is removed by being again heated, as also a scale. It is drawn thro' a hole in a by the nippers & the whole machine being turned by water. Crooked wire is straightened by means of fig. 2. the rolls of wire are got off the wheel A in fig I^r by removing the peg D —

The calx is taken off the wire by putting it water impregnated with oil of vitriol, or other wise by putting many rolls of it into barrels & turning them round, by means of wh. friction the calx is removed — —

To grind steel or Iron they use the common grinding stones — many of these are sometimes put upon the same axis and turned by a steam engine — any one of these stones may be stopt by slipping it off the axis — For polishing steel they use ~~wh~~ grinders of wood, pewter, & lead — putty is used for poli-


1
a
(d)
water


I
a
f
2
water

2

water.

ing & the last gloss is given with the hand —
The rest of Iron is also used —
In order to grind a piece of steel of any particu-
lar form (as octagonal) they take a handle
of that form & fix it on the steel & grind
it in such a wheel as this — they lay the handle
upon the transverse beam a — & by turning it from
one side to the other the steel assumes the same form
they polish it then on a pewter wheel — buttons
made in this way —

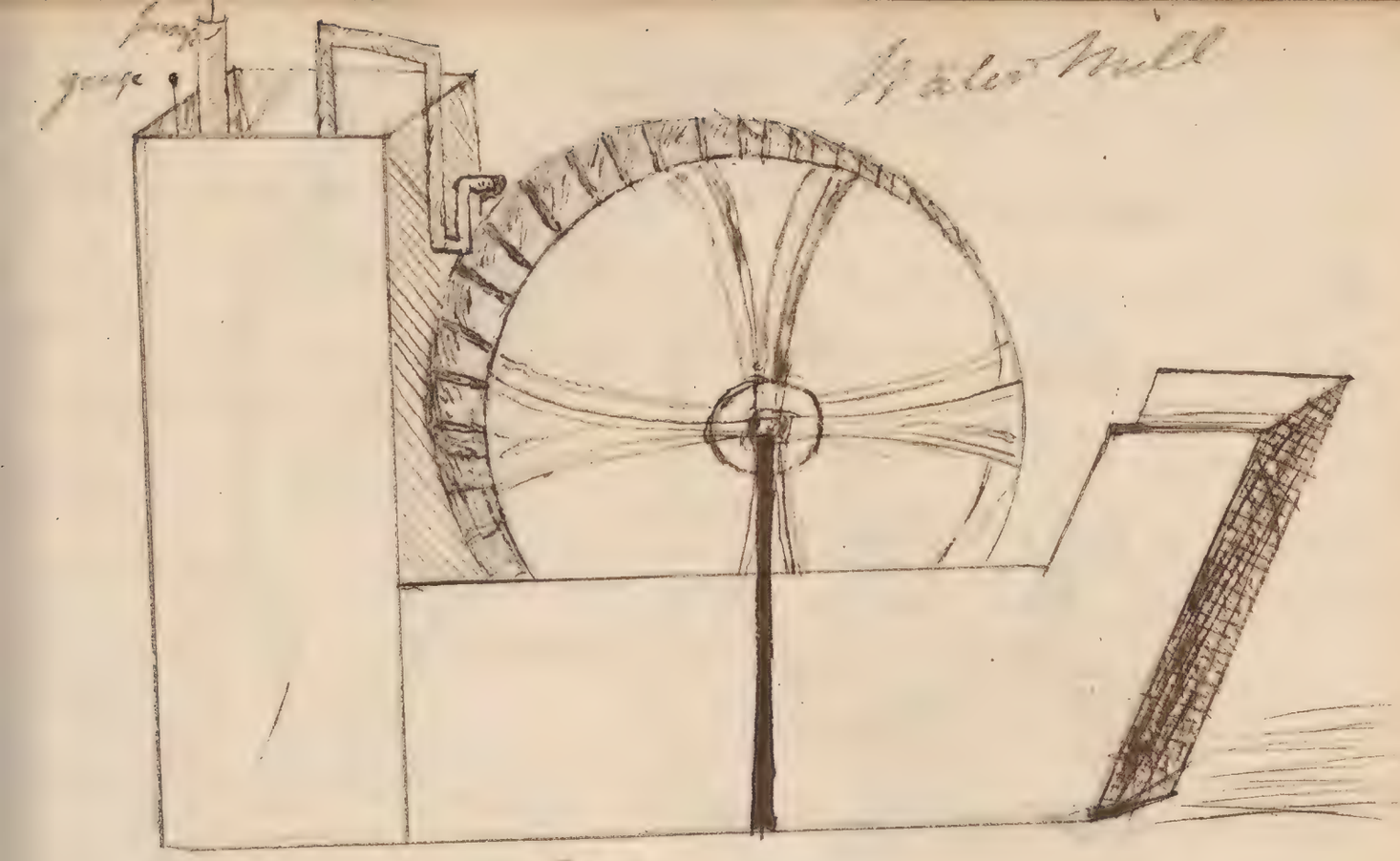
a

Water Mill.

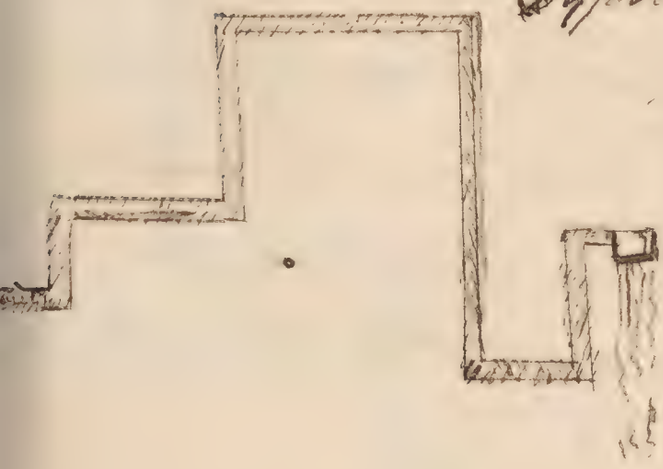
In float wheels the greatest effect is produced when the velocity of ye ~~stream~~ wheel is $\frac{1}{3}$ of that of the ~~stream~~ stream. In large overshot wheels the greatest possible effect is produced when the velocity of the wheel is the least possible — because a tooth wheel may be put to the axis & this will move with much greater velocity than the wheel itself & by the addition of another tooth wheel to this the velocity may be continually encreased. It carried up 2 lb in 24" & 5 lb in 39" 10 feet high. The wheel A is fixd on ye axis and the weight is raised by that means —

In undershot waterwheels as has been said the greatest effect is produced when the velocity of ye wheel is $\frac{1}{3}$ of that of ye stream. Effect is as the cube of ye velocity of ye water.

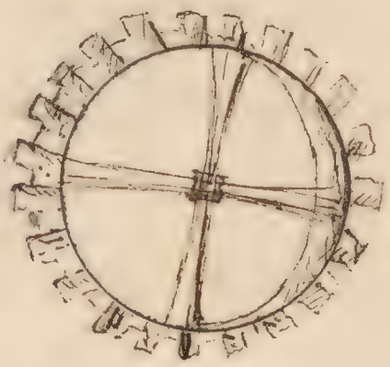
Overshot wheels move with much less water than undershot —

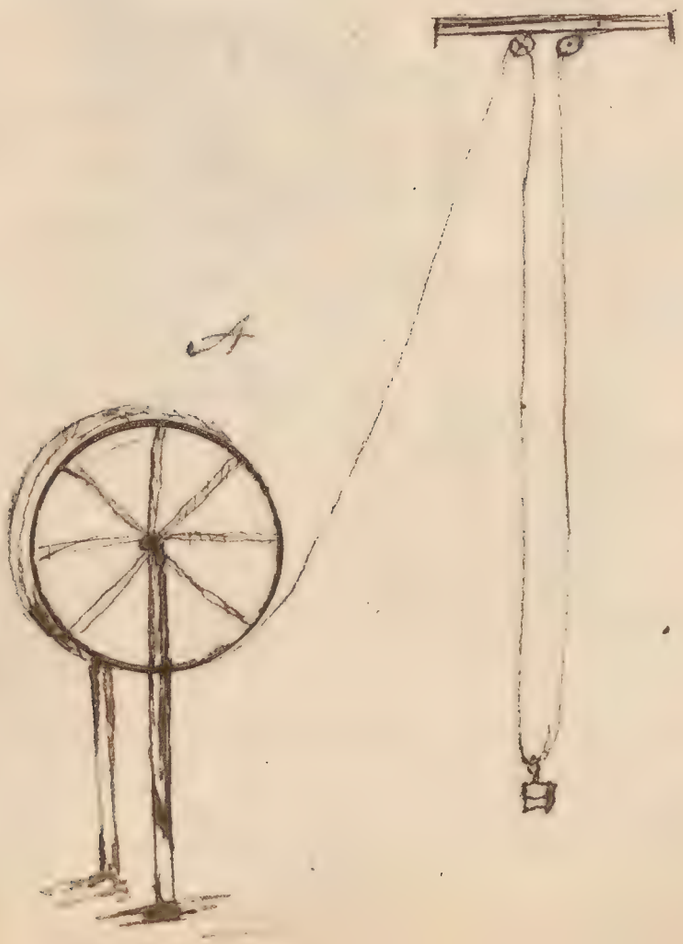


Syphon



Float Wheel





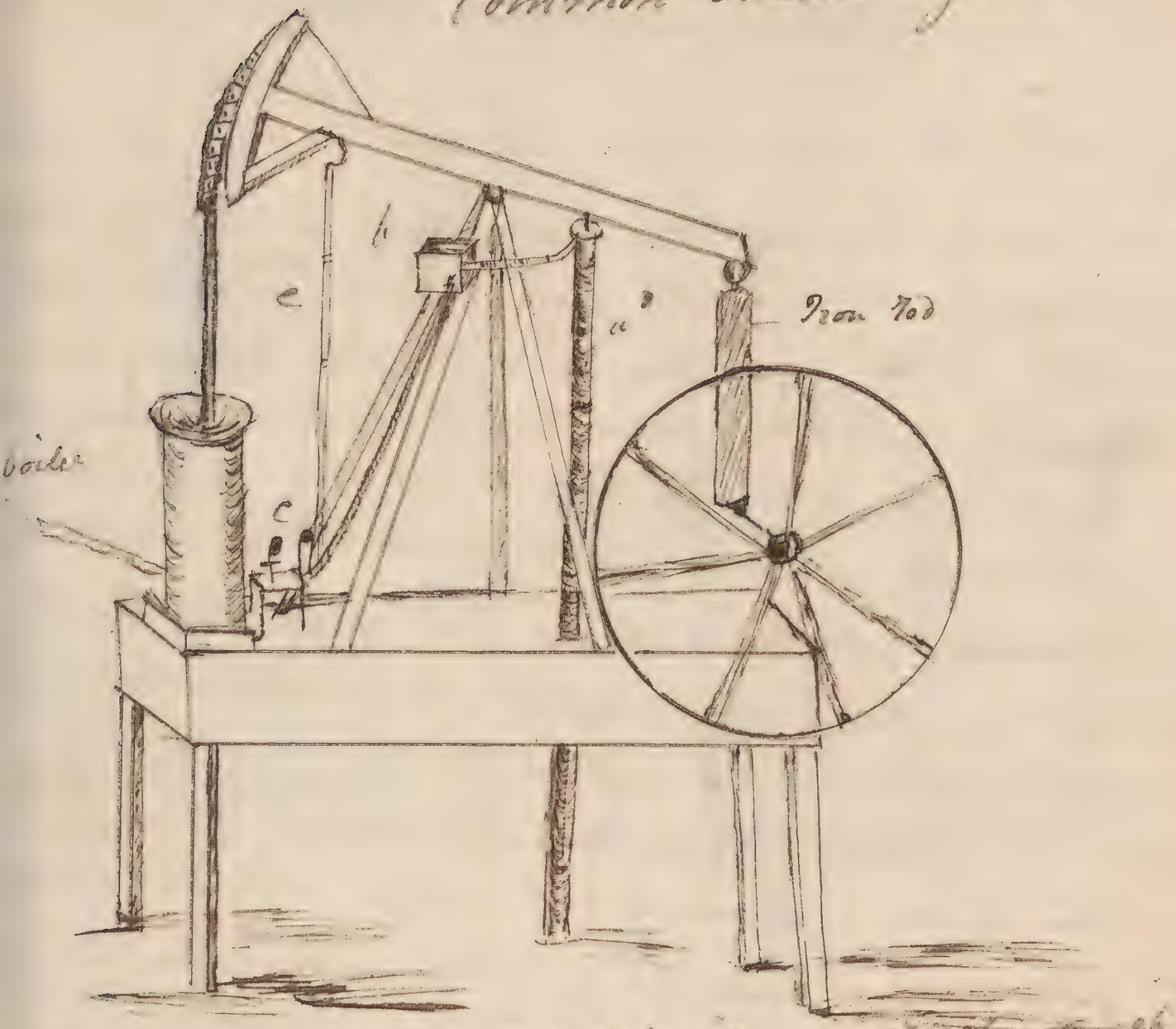
Steam Engine.

The water in the cistern being so much below the piston forms a jet d'eau in the cylinder being carried by a pipe & regulated by valves wh are opened & shut by the Rod e. The piston being supplied with steam from a boiler, this steam is condensed, by the jet d'eau. This condensation raises the piston which is balanced by the Iron Rod — & so on alternately —

The motion of the steam Engine may be regulated by means of centrifugal balls - for the balls by this motion rise up & draw d down towards the centre. d is connected with a stop valve in the valve of the steam pipe, wh is therefore regulated. If the machine go too fast the balls rise if not they lie upon the part c.

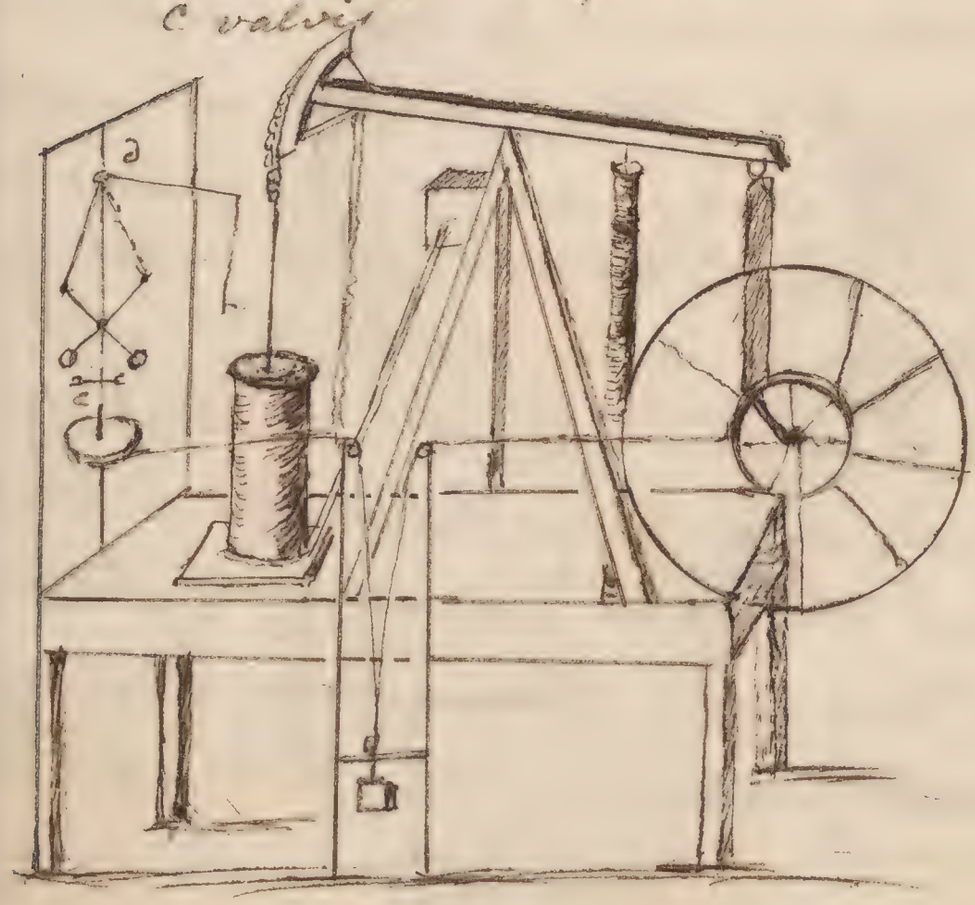
The greatest inconvenience attending the common machine is the great loss of steam to remedy this defect many Engines have been erected on different constructions. Watt & Wolf - have a patent for theirs —

Common Steam Engine.



a / pump / b / cistern of cold water [illegible]

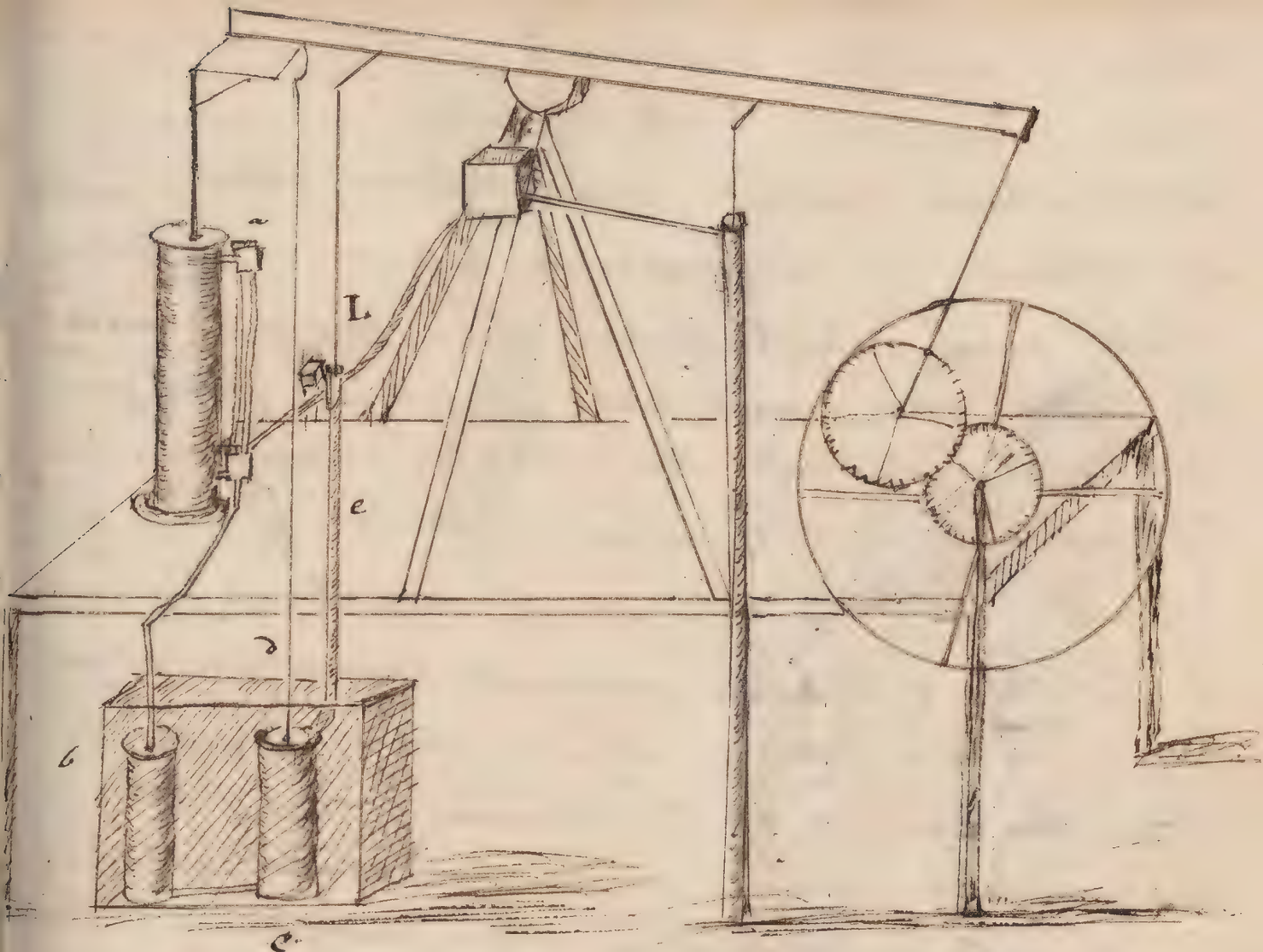
c valves

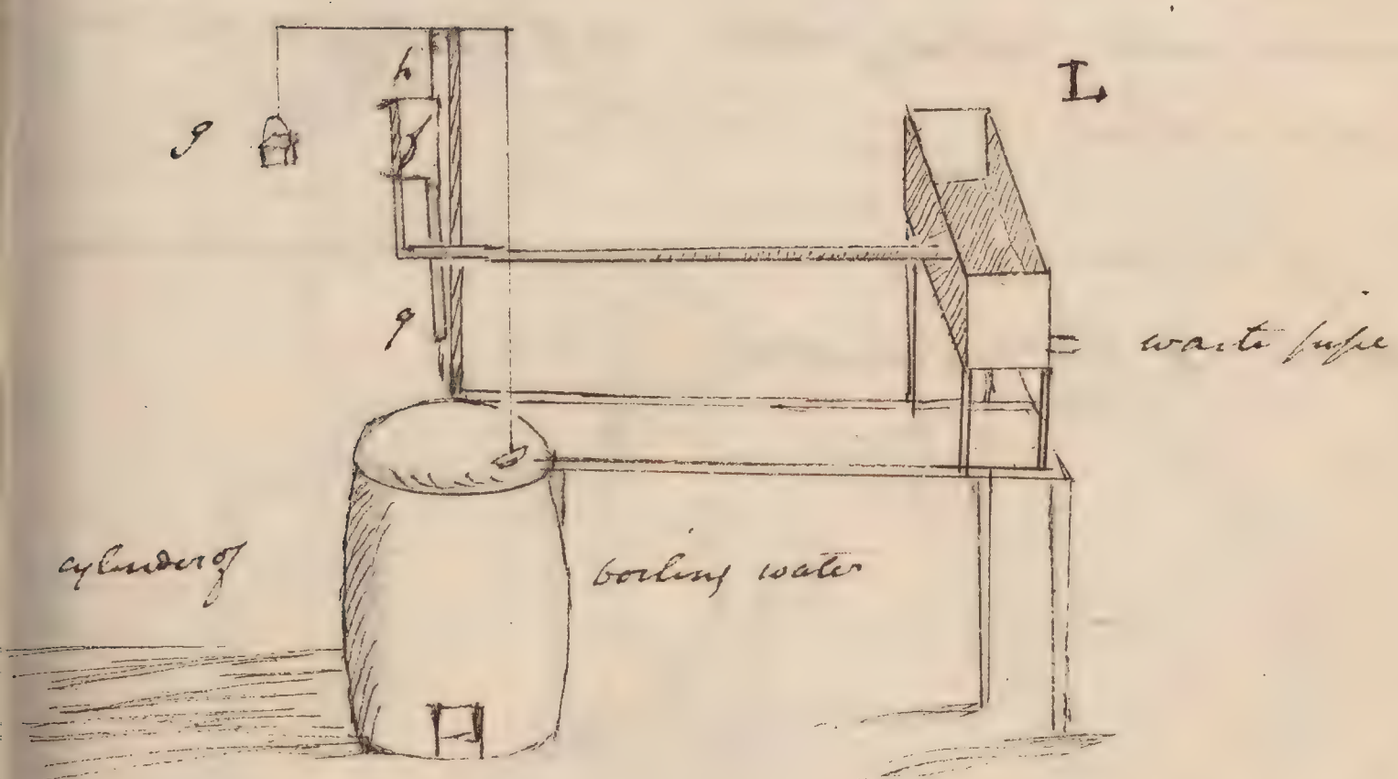


Machine for regulating the Steam Engine.

Bolton and Watt's Steam Engine.

In the first place the receiver (wh. in the common one is open at top) is closed here. The steam is conveyed into the double pipe a at the bottom nozzles & so into the cylinder & forces up the piston, it is then by another pipe conveyed into the upper nozzles & forces down the piston, the steam wh. is under the piston by the first operation (being condensed by cold water) is forced into the cylinder b. wh. is called the condensing cylinder & thence thro' a pipe into the air pump c; both the vessels being immersed in a vessel of cold water & stopt at the top, so that the steam is thoroughly condensed. ~~It~~ The whole quantity of water is then raised by the piston d from all the vessels into the pump e, whence it is pumped into the cistern L, it is conveyed thence through a pipe into the receiver f & by another pipe g into the cylinder of boiling water. In this last pipe there is a valve wh. is turned by a wire h. this wire is moved by a stone which is made to swim on the surface of the water by being nicely balanced with weights at I; so that when the water in the cylinder gets low the stone sinks with it & turns the valve in the pipe g, upon which the water immediately flows from the cistern L. The machine thus supplies itself with water. In the cistern L is also a waste pipe. — The steam in the upper part of the cylinder is forced by the piston, moving up into the nozzle & so by pipes into the vessels b & c as before

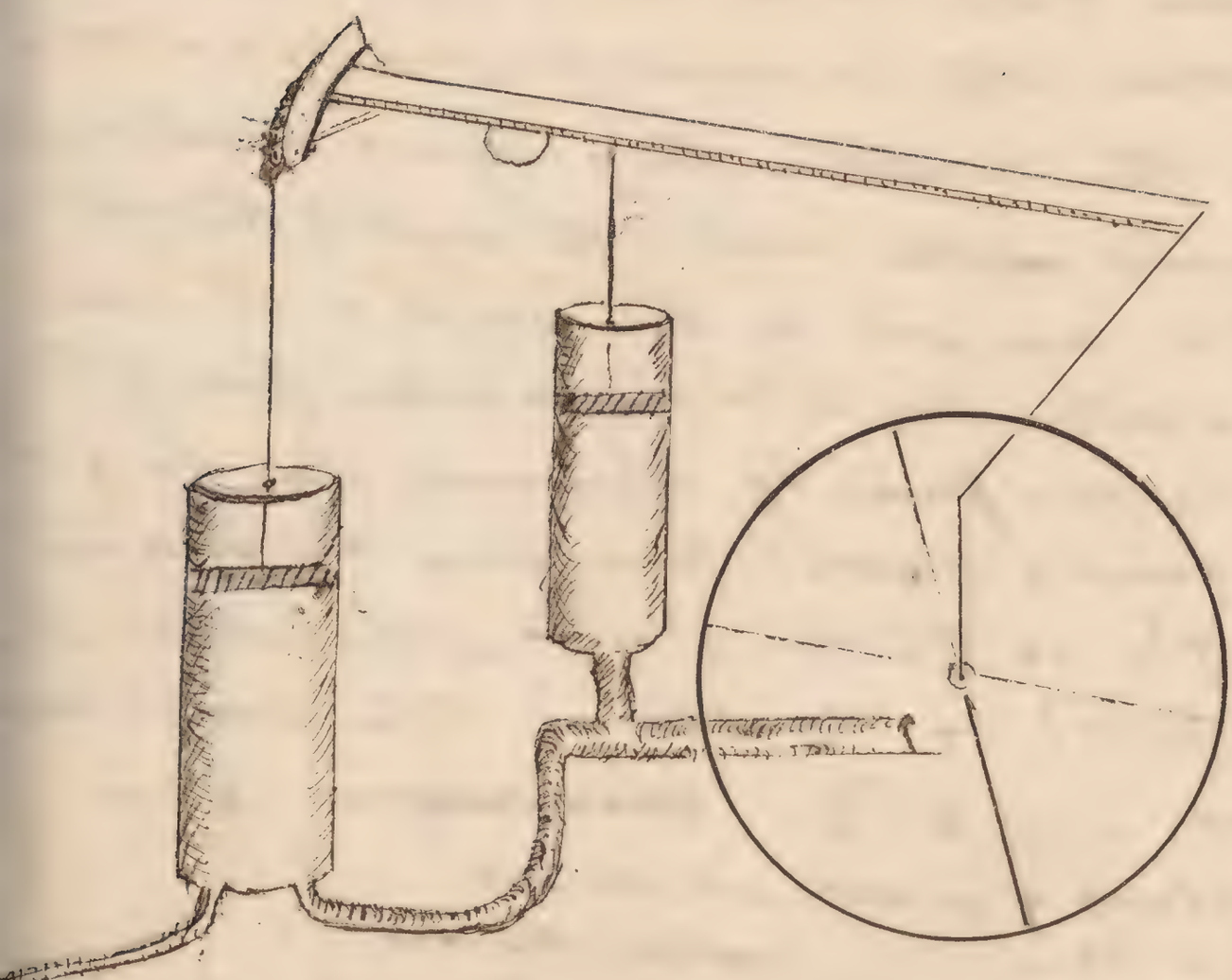




connected with the above Steam engine at L.

There is another difference in the construction of this machine. The Fly wheel is moved by two tooth wheels called sun & planet wheels instead of a crank as the common engine. The planet wheel being much larger than the sun wheel the latter goes round twice whilst the first goes only once, so that the velocity is much encreased. The velocity by this means is double of that by the crank. The common machine according to Bolton & Watts account consumes about 6 cwt of fuel in an hour. theirs about 3 cwt. so that the saving by this machine is very great. They burn not only coals but slack, which would not serve for any other purpose. They estimate the force of these machines by Horsepowers. The machine drawn here is about 30 horsepowers. & the erection of it would cost about £1060. one of 50 horse powers about £1500.

A Steam Engine on another construction of about 14 horse powers.



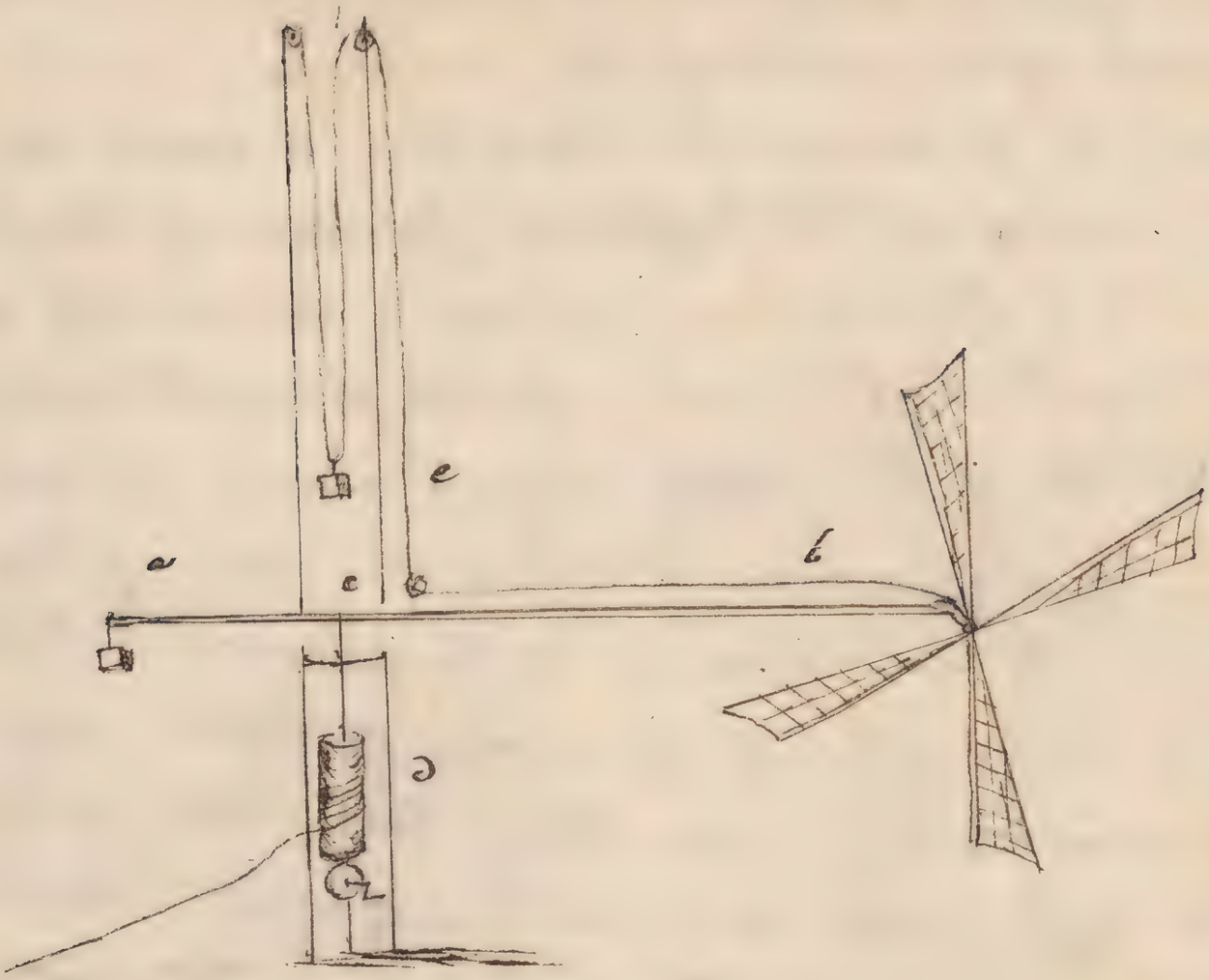
Water mills, & Steam Engines having been treated of, we come next to Windmills.

The sails being turned directly by the wind & the force of the wind to be resolved, we shall have part of it acting obliquely; this is the cause of the motion of ye sails.

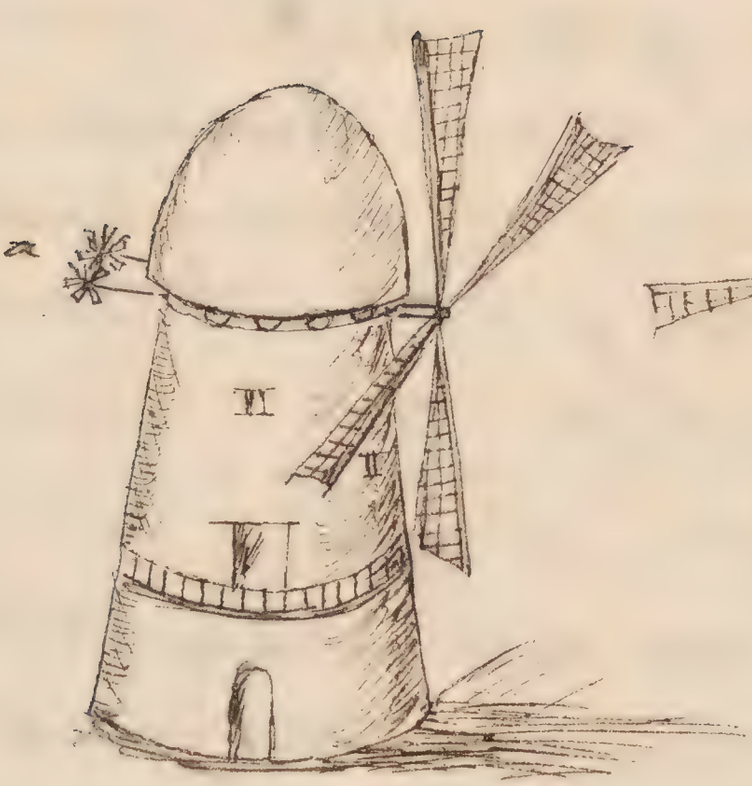
The sails may be set at any angle by the mean of screws. In order to find what angle is the best they use a machine of this kind.

The sails are made to describe a circle of wh the radius about the centre, the motion is given them by pulling the cord inwound round the cylinder d, which when the machine stops is wound up again by a wheel. By this revolution they acquire a motion wh is varied ~~wh the~~ accordg to the angle of the sails and is measured by the weight e wh is raised to a certain height during a certain space of time. It has been found by experiments that the greatest quantity of work is done when the sails are at 7° ½ at the top, & 22° at the bottom. This was proved by Smeaton. The greatest maximum is 35° ½. ~~The average is~~ When

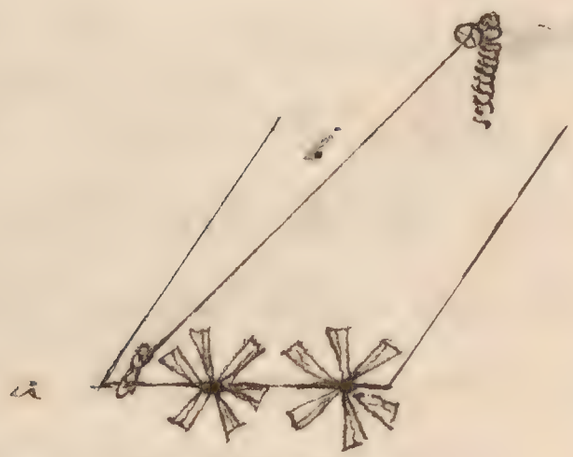
Velocity of ye sails with the load
is to do ——— without the load
As 2 : 3 — the greatest effect is produced


e
a
c
b
d

An optical deception is produced in the going round of the sails of this machine; as the sail seem to go round one way & then to return the other. It is owing to the different positions of the front & back of the sails. As it is absolutely necessary that the sails should front the wind The Top of the mill moves round. It was usually the custom to turn this top by long poles wh. came from it to the ground, but now they turn the top by means of little sails &. The wind acting upon these turns the axis & the tooth wheel at the extremity of it. This tooth wheel fits into another which turns the rod b with a tooth wheel at the other end of it. This wheel fits into a screw & by this means the top is turned round to the wind. It moves easily upon rollers in order to prevent friction. The wheel upon the axis of the great sails (fig B) turns another wheel & the axis c & this again turns the grinding stone. Windmills are used for many purposes besides grinding corn; such as draining marshes &c.


a
VI
II

B.
C


a

Wheels

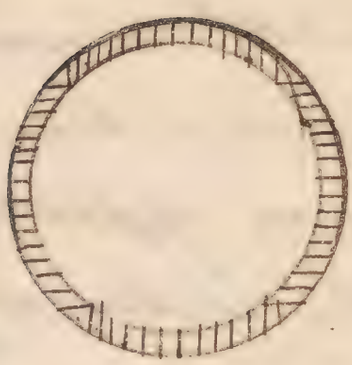
Motion in machines is communicated by tooth wheels, & may be varied by changing the diameters of the wheels. For wheels wh. have the largest diameters must be a longer time in turning round their axes than those of a less — There are three sorts of tooth wheels. Face wheels. Concave wheels. Bevil wheels.

Face wheels are those wh. have their teeth on the edges. Concave — those wh. have their teeth on the side but wh. teeth are parallel to one another and a little concave — Bevil wheels are those wh. have their teeth on the side but these teeth oblique. In order to make the face wheel fit these wheels. The two wheels must be put together & the point marked where the two axes meet, & then the teeth of the Bevil wheel cut. These have many advantages over the others Concave wheels — In mill work they use cog wheels. The cogs are made round at the top in order that the wheel may roll & not slip.

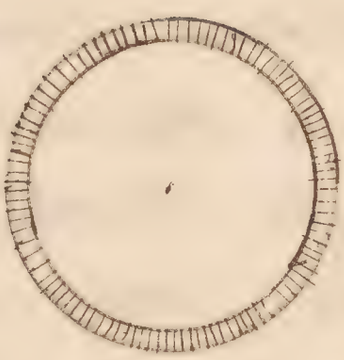
Motion is also communicated by screws acted upon by wheels — or by a peg acted upon by the teeth of ye wheel —

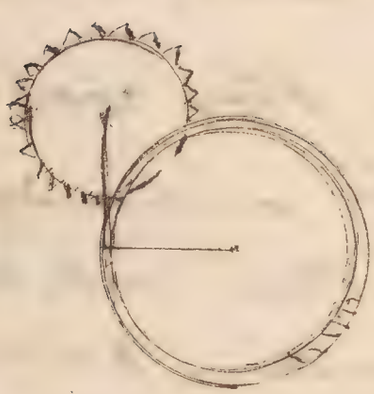
Face Wheel

Concave Wheel

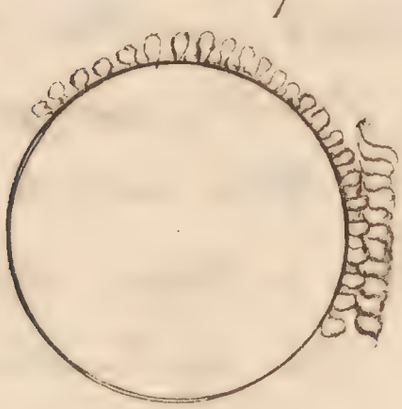


Bevel Wheel



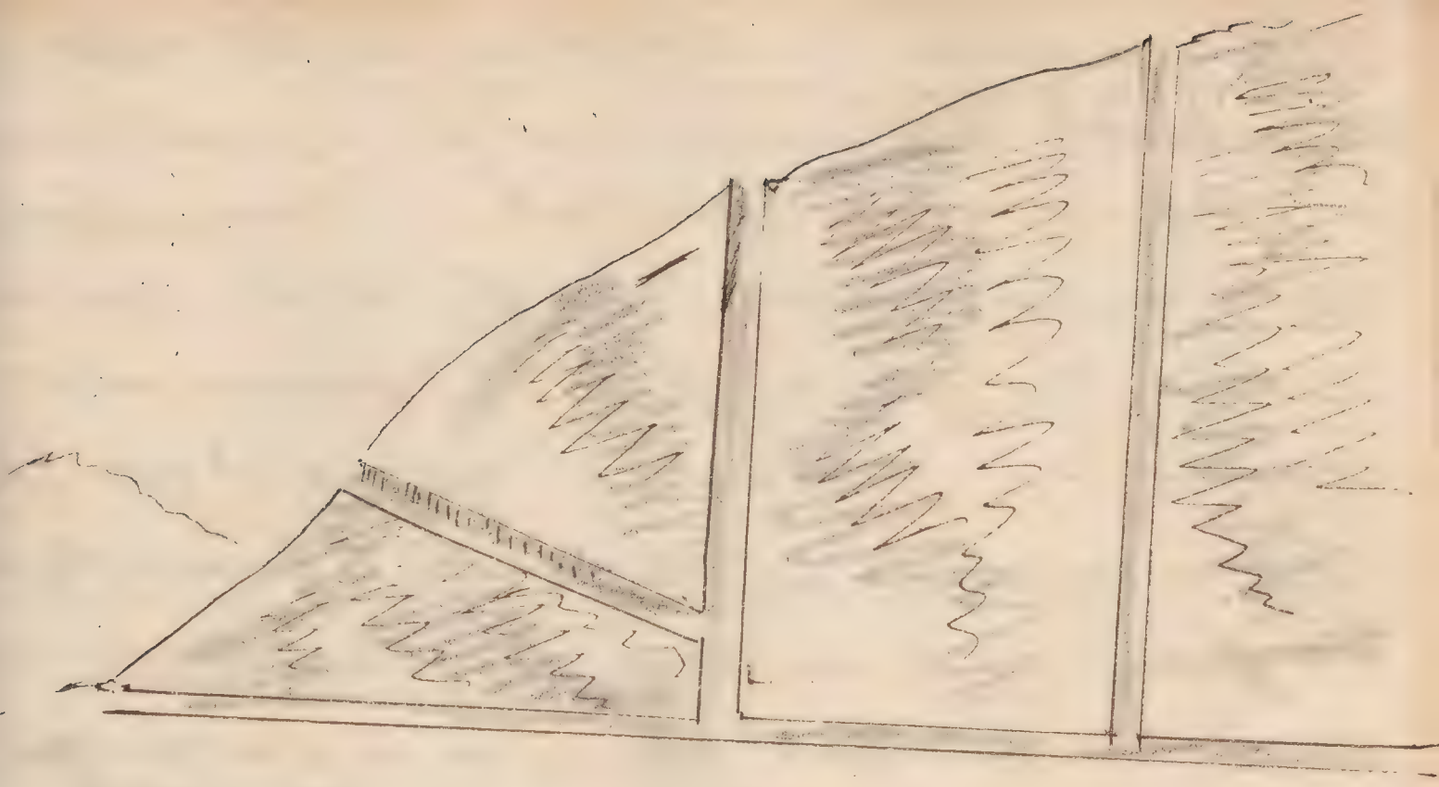


Cog Wheel –



Mines.

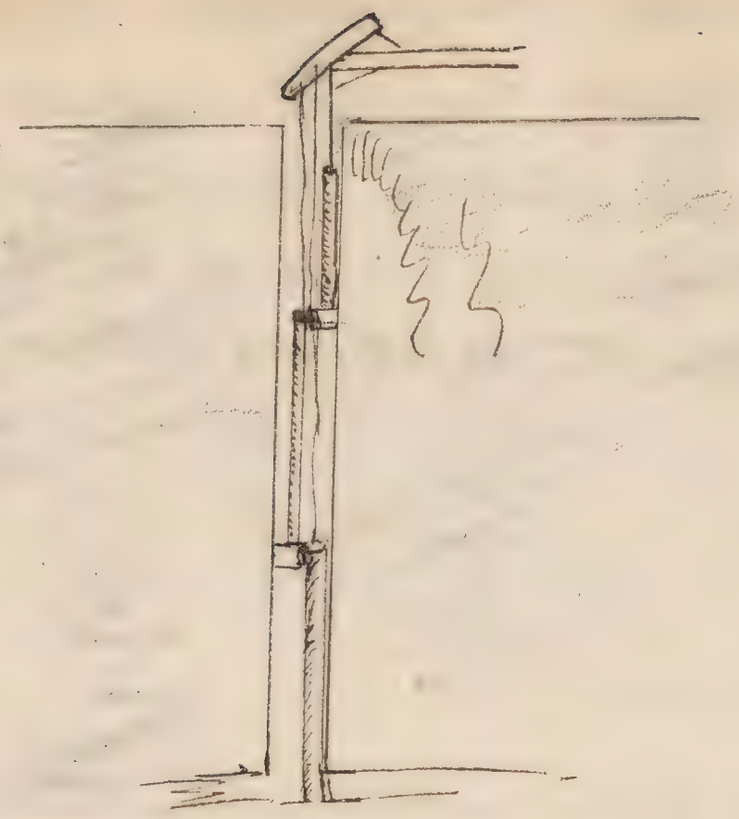
They use different methods of coming at the ore, sometimes where the ore permits they lay the mine quite open to the day. Parys mountain mine is laid open. The ore of lead lies always in veins, (or chasms of the earth formed by some concussion) & these veins lie sometimes horizontally, sometimes approaching the surface of the earth. When they cannot lay the ore open to the day they sink a shaft and drive levels to take off the water. They then trace the vein, & the ore is drawn up thro' the shaft. If they have no opportunity of driving levels, they raise the water by steam Engines. If the shaft be sunk in loose earth, to prevent it crumbling in upon them, they coat it with brick. In order to do this, ~~as they sink~~ they leave supports of earth & on them build the wall. They proceed thus sinking downwards. If in their progress they meet with sand, they would certainly stop (as the sand will not admit of a wall being built, nor would always fall in upon them) were they not to prevent its bad effects by letting down a large cylinder & scooping the sand out. The cylinder gradually sinks, & another cylinder being applied upon it, they thus get through the whole mass of sand



They sometimes draw a shaft into the side of a hill

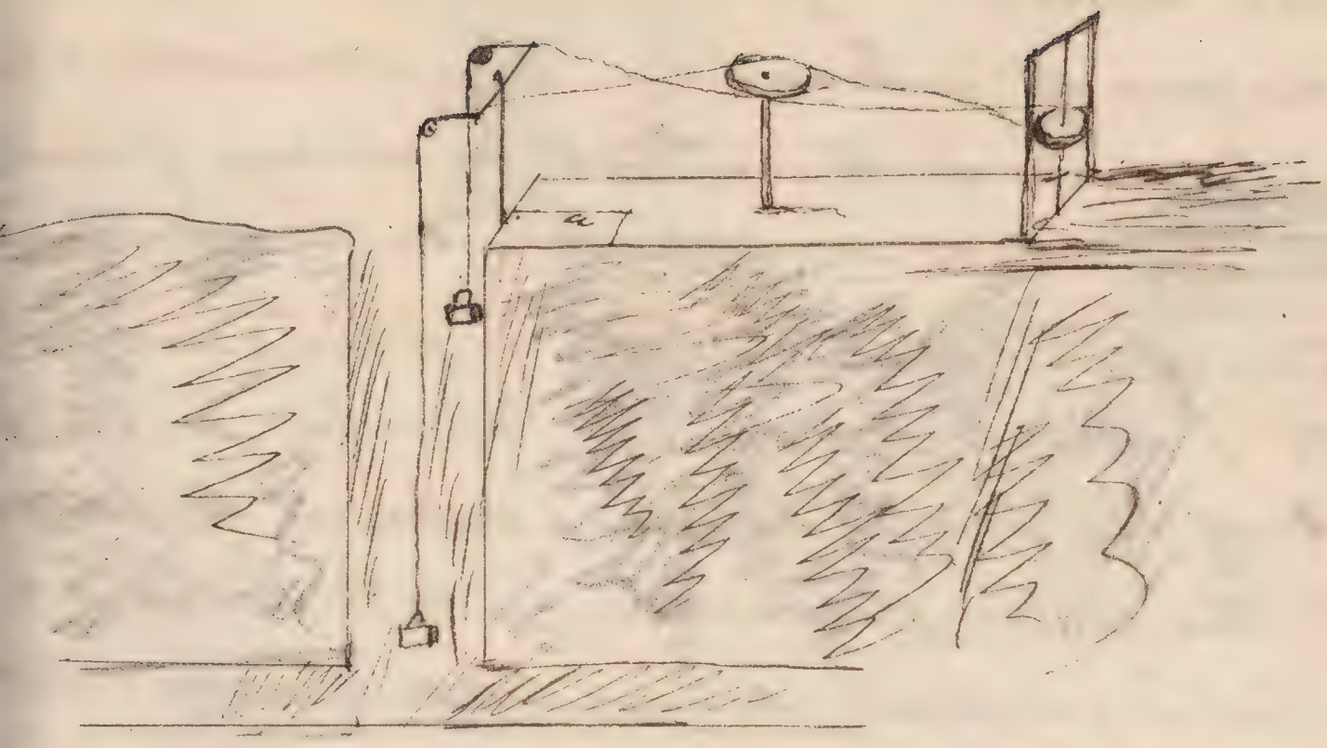
They sometimes build a brick wall upon a ~~the cylinder~~ circle of Iron & proceed as in the cylinder, ~~that~~ sinking with it the wall remains as a defence against the sand. They experience great inconvenience from the water, but this is generally got rid of, in the manner above mentioned. However in raising it up by steam engines, as the depth is generally very ~~deep~~ great, & it not being possible to make one single pump reach down, as no pump will act the cylinder of wh. is above 30 yards in length, they make a succession of pumps, with cisterns at the top, so that the water is thus easily ~~[illegible]~~ raised. Each pump is set in the cisterns of the other pump. The mines are sometimes drained by horses. When it is practicable however, the level is the best method. The water that runs from the level is applyed to the turning of mills. In Derby shire great numbers are turned by the stream of one level. In some mines horses are continually kept at the bottom. but where the mine is in the side of a hill & has a gradual slope down the horses go in & out every day. ~~They~~ miners are subject to great inconvenience from the air. Fix'd air or choke damp, Inflammable air or fire damp. We must first mention the method getting up the materials or ore.

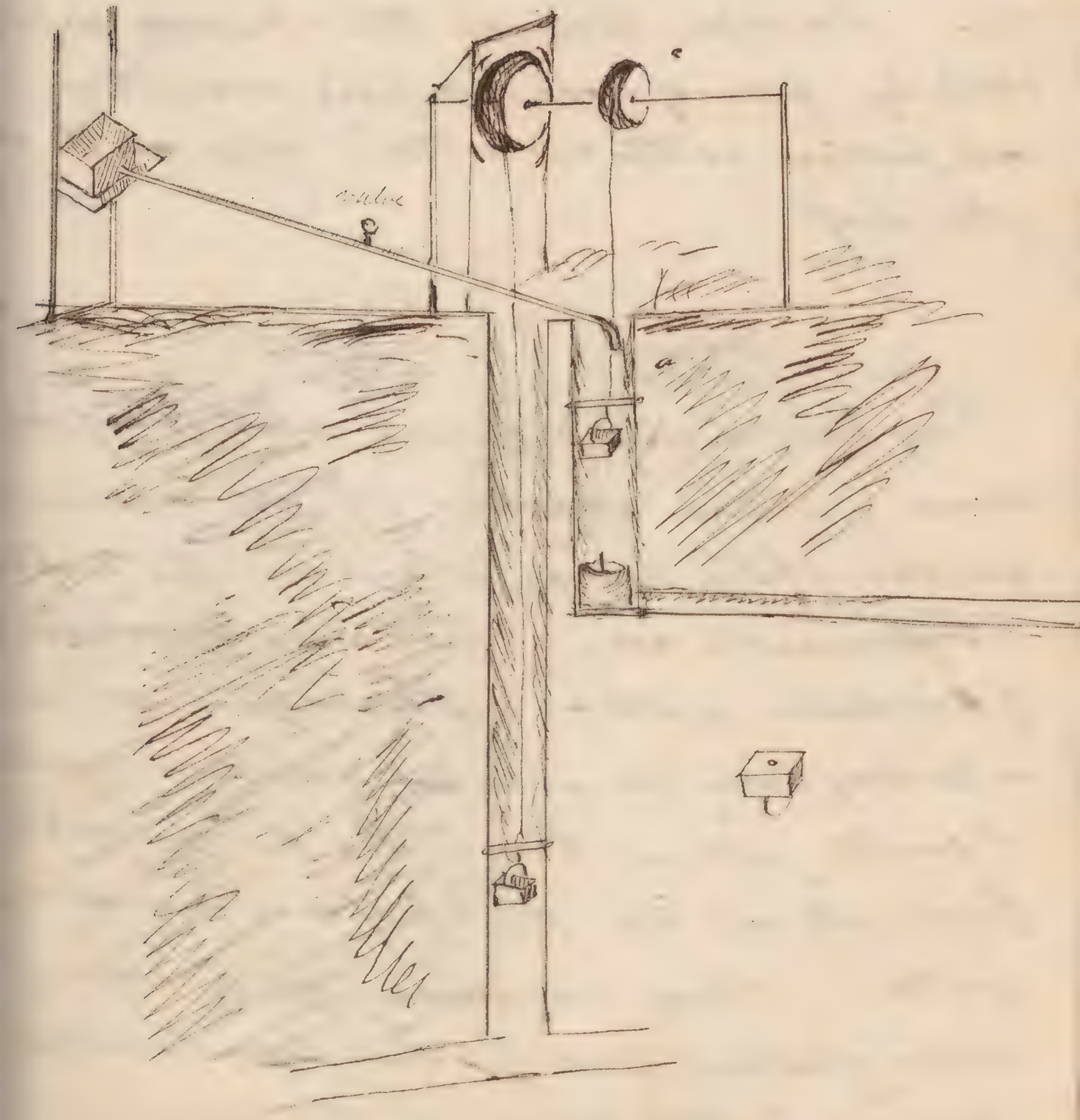
Draining



The wheels are generally turnd by a horse When one of the buckets (~~wh ascend & descend alternately~~) one of wh ascends while the other descends) is arrived at the top of the mine a door a is sled over the mouth of the mine & the materials unloaded on it. It is then sled off—

But they have another machine which they call a water whimsey— From a cistern the water is conducted thro' a pipe in which is a stop valve— above the lesser shaft a. From this shaft a level is driven so that whatever water runs into the shaft, passes out thro' the level. The water being permitted to run by turning the valve, flows into the bucket b. & by its weight forces it down and by this means turns the small wheel c, wh is on the same axis with d the large wheel. This large wheel is situated immediately over the greater shaft, & by its revolution draws up the bucket loaded with ore. When therefore the small wheel is turnd by the descent of the water bucket, the great wheel turns & draws up the ore. The deeper the shaft is the greater must be the wheel & the reverse as to the water shaft

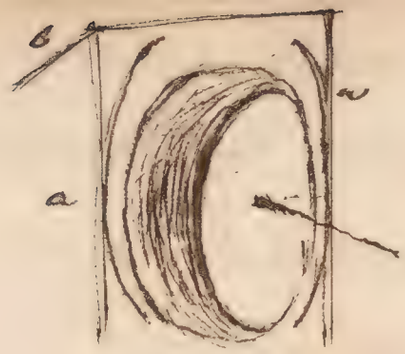


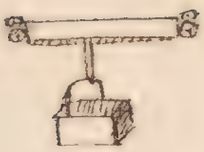


The gut wheel may be stopped at any time by means of a break. The semicircles are pressed close up the wheel by means of a block connected with the opposite side. At the bottom of the water shaft is placed a vessel with a sharp peg in it. This peg on the descent of the bucket opens a valve at the bottom and the water flows out. When the empty bucket is emptied, being a little heavier than the water bucket it sinks & draws the water bucket up. In order to make these buckets go down steadily, pieces of wood are fixed above them with pullies at the end & these run on the sides of the shaft.

Airing.

They have many different methods of airing mines. The vapours wh are noxious are the Choke damps or Fixd air, the Fire damps or Inflammable air. These arise from a want of circulation of vital air. The Inflam. air immediately takes fire when a candle is brought near. A candle will not live in the fixd air. and the flame will not live, the life of man cannot be supported. They sometimes fix the valve of a pair of bellows to a pipe that passes into the mine, and thus bad air is thus exhausted.





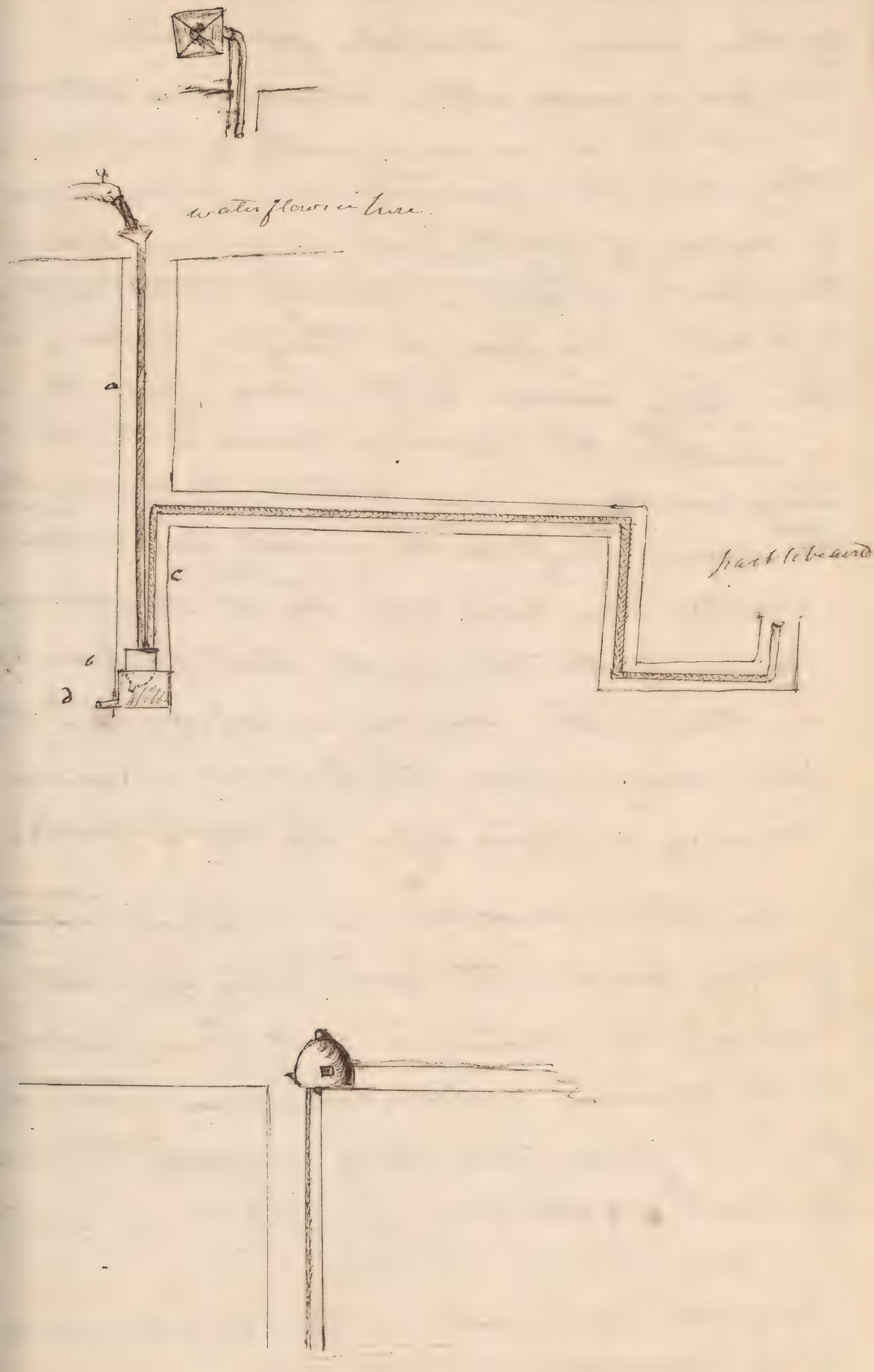
Explosion: suffocation -

They use also a machine called a horse-
head, wch they set over the mouth of the mine
exactly opposite to the wind.

They also air them by water. The water
wch is let into the pipe a forces down in
to the vessel b a quantity of air, wch being forcibly
immersed in another vessel full of water, so that
the air cannot escape, but is forced up another
pipe c thro several other pipes till it arrives
at the place required to be aired. The water
runs off thro a pipe ab d.

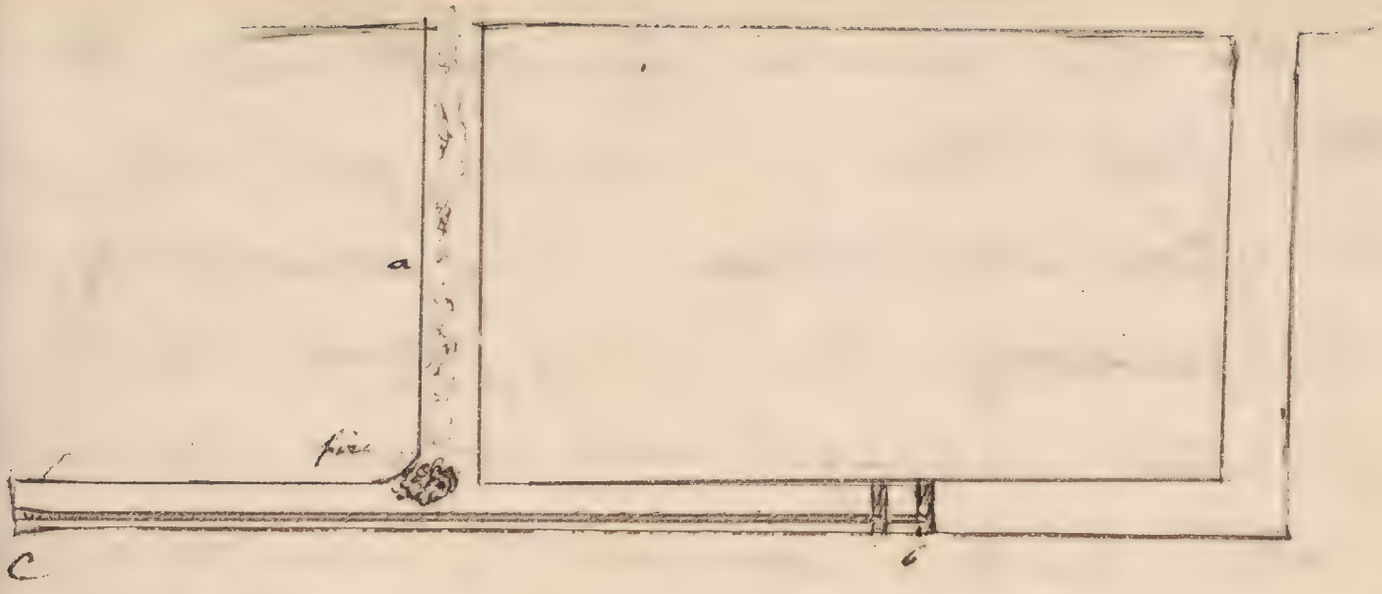
They sometimes use a furnace at the top.
This is supplied with air by means of a pipe
which passes to the part required to be aired.
It therefore exhausts all the bad air, and a circula-
tion takes place, as the vacuum is filled from the
other side of the shaft.

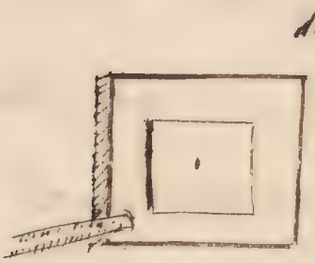
In coal mines they make the fire at the
bottom of the shaft, & as coals are so plentiful
exceedingly large fires are made wch make the air in


water flows in here.
a
c
b
d
part to be avoid

culate a great length. At Whitehaven the air by this means circulates for 6 miles.
The fire is made at the bottom of one of the shafts (a) and the air is consequently drawn down the other, but it is prevented having a free passage by means of double doors (b) wh are air tight. thro' these doors a pipe is conveyd to the part required to be aird. The pure air therefore passing thro' this pipe arrives at the place where the air is wanted (c) & the bad air is drawn to the fire.
They sometimes have baskets drawn up thro' the same shaft that the smoak passes thro' by putting a fire in mouth
a candle was kept alive by all the above means.
The use of the doors in this last fig. being double is, that loaded waggons in passing thro' the doors may not let the fresh air in, as one door may be closed before the other is opened.

In their progress in making a mine ~~a shaft~~ if they meet with rock, they generally remove it by blasting it with Gunpowder.
In the remains of Roman mines marks are found wh prove that they removed the rock by heat & great fires — Shiver or shale is a black slatish substance.
They also use wooden wedges, wh when wet expand very much & crack the rocks

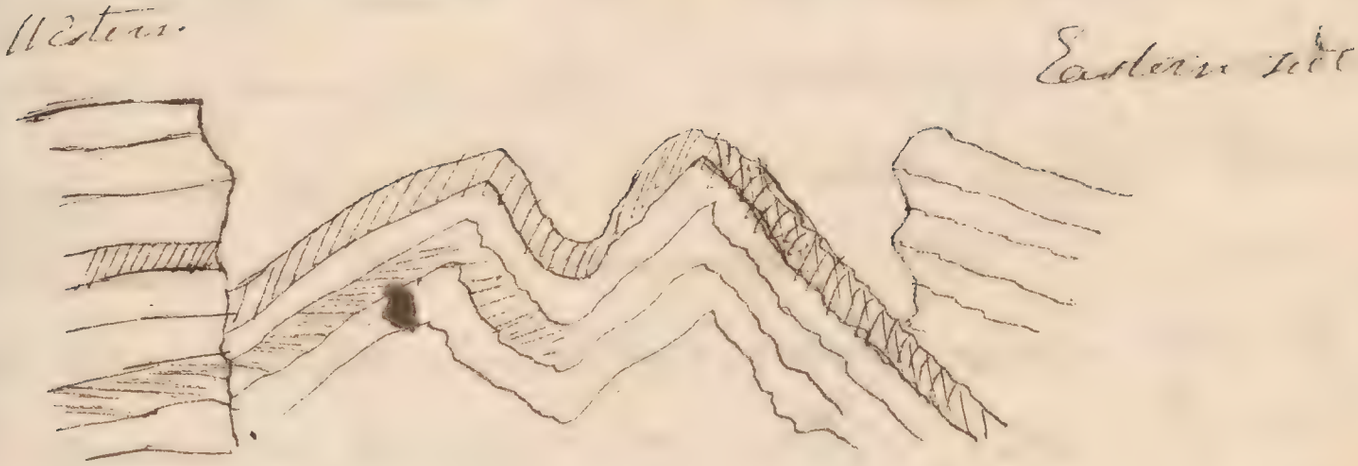

a
fire
C
c


door.

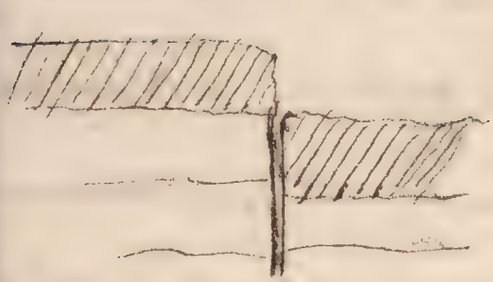
As the miners penetrate into the earth they pass thro a number of strata, which lie upon one another. They sometimes lie horizontally, but very frequently this position is changed into oblique. This alteration has been occasioned by some concussion wch has also been the cause of the fissures in the earth, wch are filled with metals, or by the upper strata, wch are frequently found wanting. What is remarkable is that tho' the upper strata are wanting, the others proceed in the same regular succession. The strata in Derbyshire lie in this form in the middle of the county, on the Eastern & western side the strata are in a different direction. The upper strata are wanting in the middle part, but the under strata go on regularly — The different strata are the on the eastern & western sides.

Argillaceous grit
Iron stone
Coal
Siliceous grit
Limestone
Shale
Toadstone
Limestone.

This upper stratum in the middle is shale or limestone, & the under strata lies answer to those of the eastern & western sides


Western.
Eastern dip

Lead runs in veins & strings. When the vein has been traced some time it runs into a set of little veins which are of no value & are called strings, or perhaps entirely stops. These strings possibly unite again & vein is as productive as before. The sudden stopping of the vein is owing to the stratum in wh it runs having been displaced, if it is again found it is very productive. Possibly a perpendicular vein & an horizontal one may meet there as there is always a fissure. The perpendic. veins are called Rake veins; the horizontal ones "pipe veins." It is observed by the miners that if the veins have not stone checks i.e. does not run thro' stone it is not so good as if it did. It generally does run thro' stone, but sometimes thro' shale. The ore is divided into several sorts, according to the size of the grains when struck with the hammer, Bing, peasy, Beland. The contractors claim a privilege of not paying tether to the land owner, or clergyman for the Beland i.e. the least. Many lawsuits have arisen on this subject. It appeared that according as it was struck it became one or the other. The workmen sometimes concrete stones wh when struck with the tools make a crackling noise, & ~~[illegible]~~ in a little time



split. They call this Slingsode, & take care to get out of the way when they hear the noise, as great masses of stone fall down, by wh. they are much assisted in their work. This is something like the effect ~~[illegible]~~ produced on unannealed glass by the touch of a small piece of flint, which immediately breaks. In order to find the direction of the mines they use telescopes, & compasses. In order to discover the veins, they examine the banks of rivers, or ground washed up by torrents, or even make artificial torrents. If they find any stones, wh. they know form one of the strata of a lead mine, they enquire further in the place where they are found, if the stones be rough; but if smooth they take no further notice of them as they suppose they are removed considerably from their first situation & so worn smooth.

In Derbyshire a man may sink a mine in another's property, but is bound to pay rent for the ore, & also to [illegible] keep up the boundaries of the extent his mine, upon the neglect of wh. the mine ceases to be his.

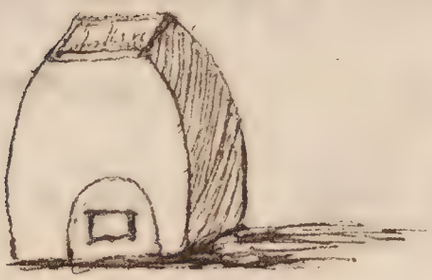
The ore is found mixd with a great quantity of spar — the fluor spar very common in Derbyshire. There are many other heterogeneous substances mixd with the lead, to separate it from

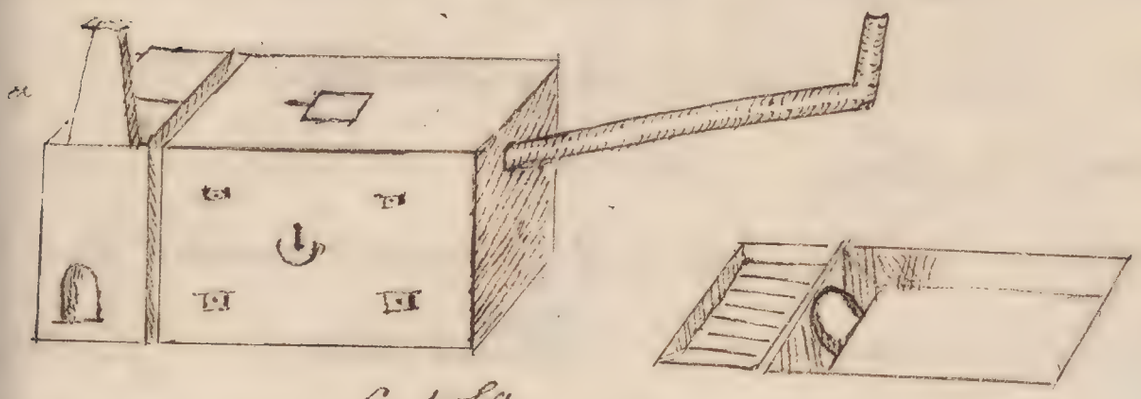
which it is broken by a hammer, & well washd.
In Croatia in 1761 a large quantity of mixd metal
flowd out, having been fluxd by the burning of a
wood. The lead is smelted on a hearth fur-
nace, ore & charcoal being layd alternately, the fire
is raised by bellows moved by a water wheel
This furnace is used also for extracting ye lead from the slag
left in former operation. or instead of this
It is ~~then~~ placed in a Cupola furnace.
The lead does not come in contact with the fire
but is acted upon by the reverberation of ye
flame from the top of the furnace. The draught
is between the grate & the Chimney. a the
flame passing to the chimney strikes on the
roof & is reverberated on the ore. Ore about 6
hours in smelting. Beland is also melted in
this furnace, but dissipated in a flaghearth.
The slag or scoria wh. swims at the top is
thickend with abt a bushel of lime to a ton of lead
so that it is not then near so liquid as the lead
wh. accordingly flows from it into a concavity
at the bottom of the furnace. It flows out thro' a
hole on one side of the furnace, wh. is stopped during
the smelting. laded into moulds or pigs-

The lead is then rolled into sheets-
As in the smelting a great quantity of the lead
is sublimd, it is caught in an horizontal Chimney

Slag hearth

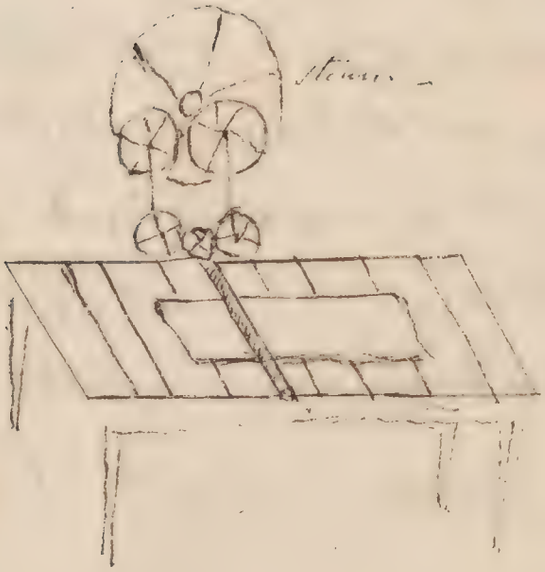
bellows behind





Cupola

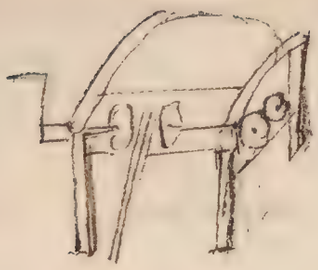
/ to regulate the heat -



This was first suggested by Bishop Watson
When rolled it is slit, & put in a Glazier's vice
to make window lead. In order to extract
silver from lead the ore is smelted in open
air when the lead calcines & the silver remains
unaltered. The vessel is very shallow that the
surface may be large. The dross or calx is called
Litharge. It is generally red if much heated, but it
is of many colours. Red Lead is formed
from calcined lead or litharge. It is put into
a furnace in wh. are partition walls, & fire in the
middle. the lead on each side. The fire drawn over
& is reverberated on the lead. the calx drawn off
ground & washed. It is then yellow. It is put into
the furnace again & stirred & by the flame of the pit coal
it becomes in 48 hours Red lead.

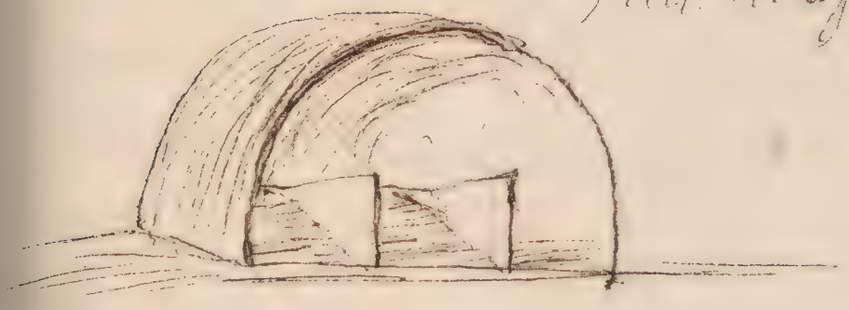
White lead is formed by an acetous acid's ac-
ting on the surface of the lead, wh. it corrodes
in white flakes. Great rolls of lead are put in
tubs of vinegar. the scales are ground — The
vinegar is raised in vapour by horseding.
Ceruse or litharge ~~dissolved~~ boiled in distilled
vinegar & crystallized gives the saccharum
saturni. Lead helps the vitrification
of bodies — litharge is more valuable than Red lead

See Watson's Essay. vol. 3



glazing vie -

Red lead furnace



The color exhibited on the surface of melted lead are in the following succession — yellow, purple blue, — yellow, purple, green, — Dark green — (according to Newton's theory)

Tin.

Tin lies in veins like lead, sometimes in strata. It is deposited by rivers. Cornwall. At mounts bay in Cornwall there is a tin mine under the sea. Steam only be come at when the tide ebbs very far. It is worked by means of cylinders, & is drained by steam engines on land, & horizontal rods. To prevent the sea from coming in the cylinders are closely stopt. Tin melts with less heat than almost any metal. But a mixture of tin & lead melts with still less. It is melted & laded into blocks, & in order to certify its purity is stamped by persons appointed by the Duke of Cornwall. Lead being much cheaper is very much mixed with it. The great use of this metal, is in tinning copper or Iron vessels. Copper vessels are tinned either with a composition of tin lead, & pewter, or with pure tin. In order to tin copper the vessel is rubbed perfectly bright, so that there may be no remains of rust, then washed with sal ammoniac, & then being heated is dipped into the melted tin, wh incorporates with it. In order to tin Iron plates The plates are rubbed quite bright, & put into an Iron pot filled with melted tin. The surface of the melted tin is covered with suet, to prevent calcination The tin unites with the iron.

Iron stirrups, buckles, bits, are covered with tin by dipping them in a cabaret when they are made. Andrew Yarranton brought the method of making tin plates out of Saxony into England. 1670. The least mixture of tin with lead, makes the lead so harsh that the plumbers can not work it — The harshness of old lead may be attributed to the tin in the solder —

Copper.

Copper runs in veins as lead. great quantity imported from ye East Indies. Japan The most productive British Copper mines are those of Ecton in ~~Dr~~ Staffordshire, & Paris mountain in Anglesey. It has the bed of ore 40 feet in thickness The methods of proceeding are similar to those in Iron, & Lead. Copper is granulated by dropping it into water — It is of very extensive use as most utensils &c &c are made of it. It is converted into Brass by the addition of Zinc. The ores of Zinc are Calamine & Blende or Black Jack: Blende resembles lead very much. Tho' it has a much more metallic appearance, the Calamine wh. resembles limestone, contains a much greater quantity of ~~metal~~ Zinc. Calamine is found in Derbyshire Flintshire, & at Mendip — It is generally found in lead mines. The workmen say that when it appears in lead mines in any great quantity it shows a deficiency of lead — It is calcined picked, & washed, & made up for sale. It is united with phlogiston in order to yield its ore. Zinc in a strong

heat burne with a very vivid flame. Zinc & Copper when melted together constitute pinch-becks. Copper is made into brass in this manner. The copper is granulated, & mixed with calamine & charcoal both powdered, & exposed for several hours to a fire not quite strong enough to melt the copper, but sufficient to unite the metallic earth of the calamine with the phlogiston of the coal. This forms a metallic substance wh penetrates the copper changing its color to yellow, & encreasing its weight. To make wire &c. the finest calamine is used & in a greater proportion. Great varieties arise in Brass from the different quantities of the calamine. Brass is lighter, more sonorous (& therefore proper for musical strings) more fusible, less liable to scale in fire, and rust in ye air. ~~But~~ This not malleable when hot, but when cold may be beat out into leaves, Dutch gold — Brass is generally turned in a common lathe. Copper is not only used for domestic purposes & bubis of great importance in the arts —

Engraving Etching, Aqua Tinta, Mezzotinta are all performed by copper —

Engraving.

The drawing is ~~placed~~ traced upon the plate by then cut by a sharp tool, the plate is then blackend with printer Ink & rolld between flannels, after it has been rubbd clean (excepting in the furrows) with the hand, & paper laid on it. This paper if written on would run, it must

be well wetted in order to fill up the interstices of the engraving. This plates are much more durable, i.e. will give a greater number of impressions than Etching or any other copperplate, as the furrows are narrower at the bottom than the top, and consequently as the plate wears, the strokes only grow thinner, whereas in etching the aqua fortis undermines the plate, & the strokes consequently become wider, so that in an impression the light parts vanish, & the dark become more so.

Etching.

The plate is heated, and a varnish called Etching ground is put on it & this is blackened by the smoke of a candle. Upon this is laid a sheet of thin paper covered with a red paint upon the side next the plate, the drawing is then laid on this and the outlines traced with a fine pointed instrument. These outlines are marked in red upon the plate. They are ~~cut out~~ scratched in order to remove the varnish, & the shadows &c are put with a needle. Aqua fortis diluted with 3 or 4 times its quantity of water is then poured on, & is prevented from running off by a row of wax on the edges of the plate. It eats all the parts that are undefended by the varnish, but upon the varnish itself it has no effect. The whole drawing then being eaten with the aqua fortis is washd, & the parts intended to be light are ~~again~~ covered with the same varnish, & the acid is again poured on. Upon this second application it eats the parts designed for shade more deeply. This is repeated ~~freque~~ two or three times, care being taken

each time to cover the lighter shades with varnish. The aqua fortis is apt to undermine the copper, & when this happens the part is raised & the plate is hammered behind till the part rises on a level with the rest. When the acid has been applied a proper number of times the whole is washed & the varnish is removed by turpentine. It is then blackened & rolled as in Engraving.

aqua Tinta.

The outline is etched; the lights are then covered over with paint, and upon this resin is dusted. The plate is then heated over the fire in order to fix the resin. aqua fortis diluted is then poured over it which eats the plate where it is undefended by resin into a number of little holes. The acid is then washed off & resin being put upon those parts which are to have ally lighter shade, the aqua fortis is again put on. They sometimes dip the plate into spirit varnish which when dried cracks into a vast number of small parts. The ~~aqua fortis~~ light parts are guarded as before, and the acid penetrates into every one of those cracks. The different degrees of shading being then obtained, the impression is taken as in Etching — But first the plate is heated in order to make it take the ink.

or sometimes the Operation is ~~performed~~ performed by painting all the light parts & painting the dark parts with honey, burnt cork, & water. The plate being

heated this rises & admits the acid.

Mezzotinto —

Was first invented by prince Rupert
The plate is punched all over with an instrument for the purpose in every direction, so that were an impression then to be taken it would be one uniform blot, after wh. they trace the drawing out upon it, & expunge with burnishers scrapers &c the dents or furrows in all the parts where the lights are to be, & thus more or less according as the lights are to be stronger or fainter. Leaving those parts black wh. are to represent the shadows or deepnings of the piece. Scraping in Mezzotinto is the most expeditious way of Engraving.

Etching in soft ground.

Trace the landscape by drawing with the hand upon the varnish put on the acid deluted a before & proceed as before. The impressions exactly resemble a drawing.

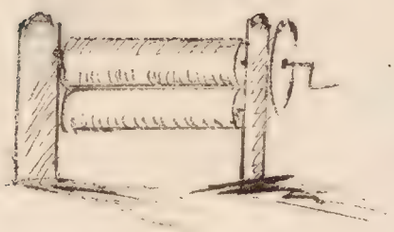
In engraving they sometimes use stippling.
Instead of shading the plate by lines as many do
they effect it by making holes with a needle.

In order to try the effect of their plate without the
trouble of rolling &c the put wet plaister of Paris
upon it, wh when dry gives an accurate impression
by this they can alter their plate if necessary.

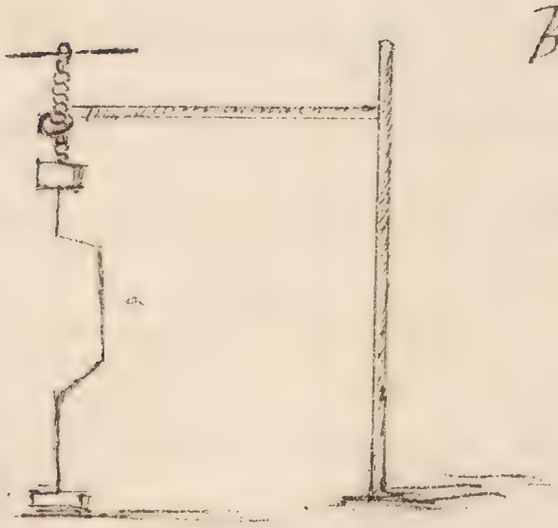
Brass is formed into a variety of shapes by
means of Lathes. Oval turning is effected by
the machine having two motions a casual & direct
Brass is made into wheels, screws &c —
It is bored by a machine of this
sort ——— It is turned at (a) by the hand.

Copper is used for covering the roofs of houses

press for rolling the engraving &c.



Borer.



press'd down by the screw

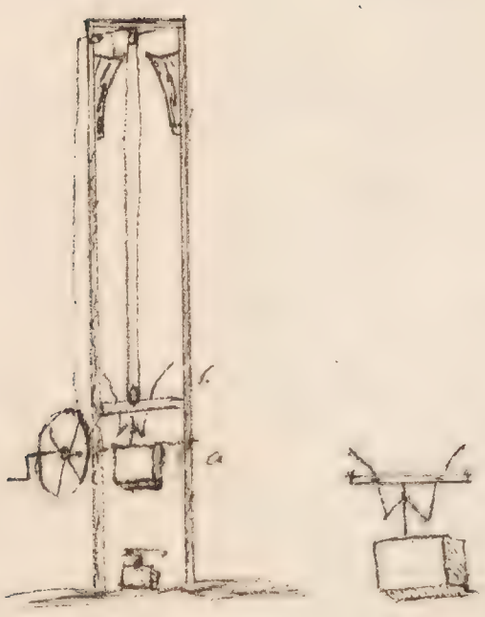
Silver.

Is obtained from lead, as has been already described. It is found also in ore.

Smelled &c. Copper is plated in the following manner. Upon a small ingot of copper they bind plate of silver with iron wire. The surface of the silver is not quite so large as that of the copper upon the edges of the latter are not covered with silver they just a little borax; & exposing the whole to a strong heat the borax melts, & contributes to melt that part of the silver to which it is contiguous, & to attach it to the copper. The whole is then rolled under steel rollers moved by a waterwheel till it is of a certain thickness, & afterward by hand rollers. The thinned is applied for lining drinking horns. One ounce of silver is rolled into a surface of 3 square feet.

It is stamped by a machine of this sort. It has a great resemblance to the pile driver. The die is placed upon a block & the plate to be stamped laid upon it. The wheel is then turned & the great stone (a) is raised by the forceps (b), which upon its arrival at the top being compressed by two projections lets go its hold, & the stone falls with great weight upon the die. The forceps immediately descends & catches hold of the stone. The metal is then completely stamped.

Stamping Engine.



Gold.

The most wonderful property of gold is its extreme malleability. It may applied on silver, by coating the silver with gold leaf, & the rod being drawn into wire the gold adheres to it. Gold may applied to silver by dissolving the gold in aqua regia, & linen rags being dipped in the solution, they take up some of the gold. These rags being burnd to ashes, & the ashes being rubbd on the silver the gold adheres to it, & is rendered visible by being well burnishd. Copper may be ~~gilt~~ gilded by putting on size & then gold leaf.

Another way of applying gold on silver or copper is this. It is calld gilding in or Moulu. An amalgam is made of gold & mercury, & spread upon the surface of the plate. The quicksilver evaporates at a low degree of heat and the gold remains. which when burnishd be gilds the copper. Iron may be gilded the same way for the quicksilver does not unite with Iron, ye by means of Blue vitriol the Iron may have a copper surface upon which the gold may be applied as before.

When the gold is fixd on the plate is warmd & rubbd with wax by bloodstones (a particularly hard stone) & burnishd after being heated again.

Gold is beat on an anvil, divided into 2rs. these are again divided again beaten, laid in Goldbeaters skin in layrs, beat on an anvil & again divided.

Pewter

...de of Tin & regulus of antimony, or Zinc —
...ce different sorts plate, trifle — ley —
Plate is used for plate, dishes &c & is the very best
pewter — Trifle for pints & quarts — ley for
...ine measures — Ley contains $\frac{1}{5}$ of lead —

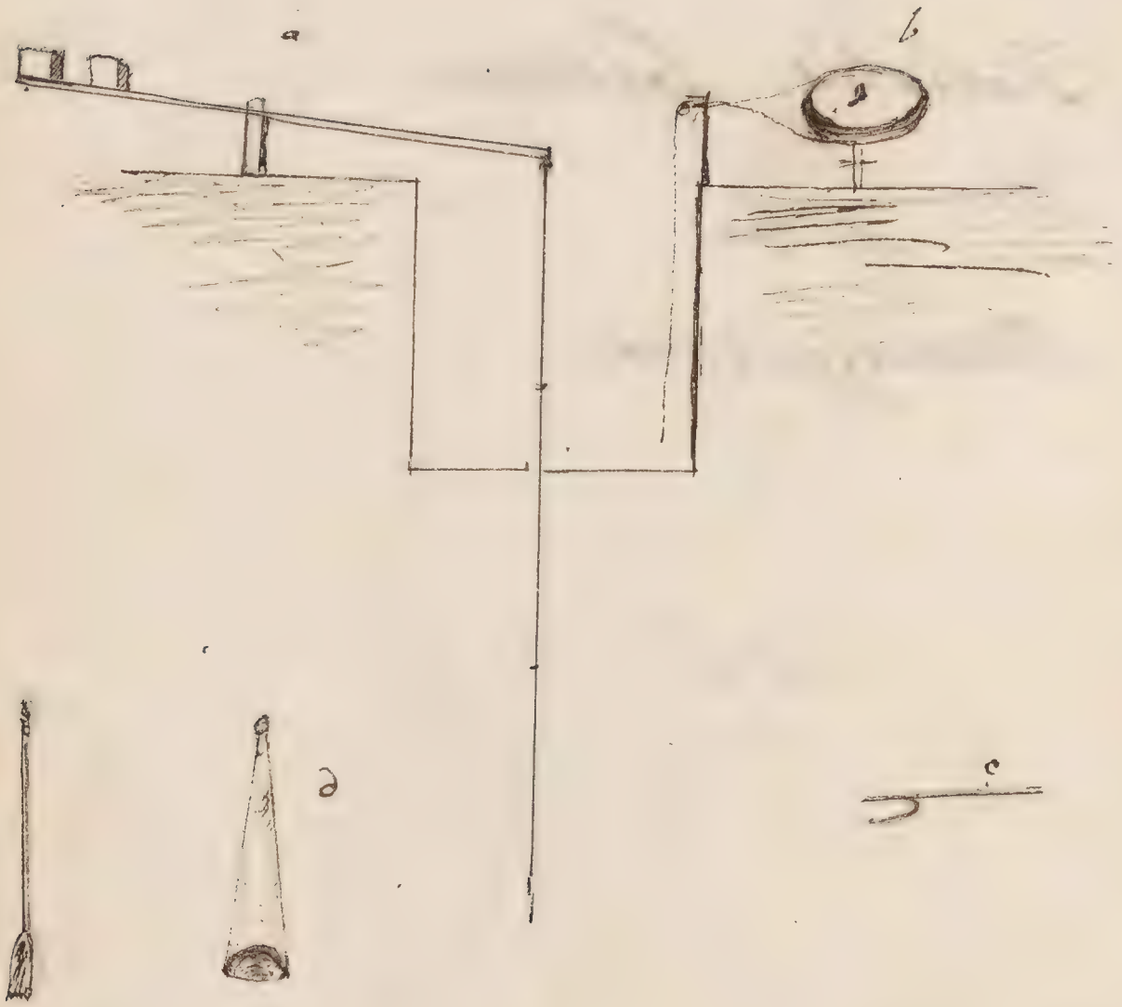
Faris's Lectures

on the

Manufactures

Vol 2.

Boring.



sludging pot.

a / the beam by wh. the rods are moved. great weights are put b
the other end in order to balance the rods. b / to draw up the ro
it may be a wheel or any machine. The rods are turned by
the handle (c). They also screw into one another. broken
rods are raised by (d)

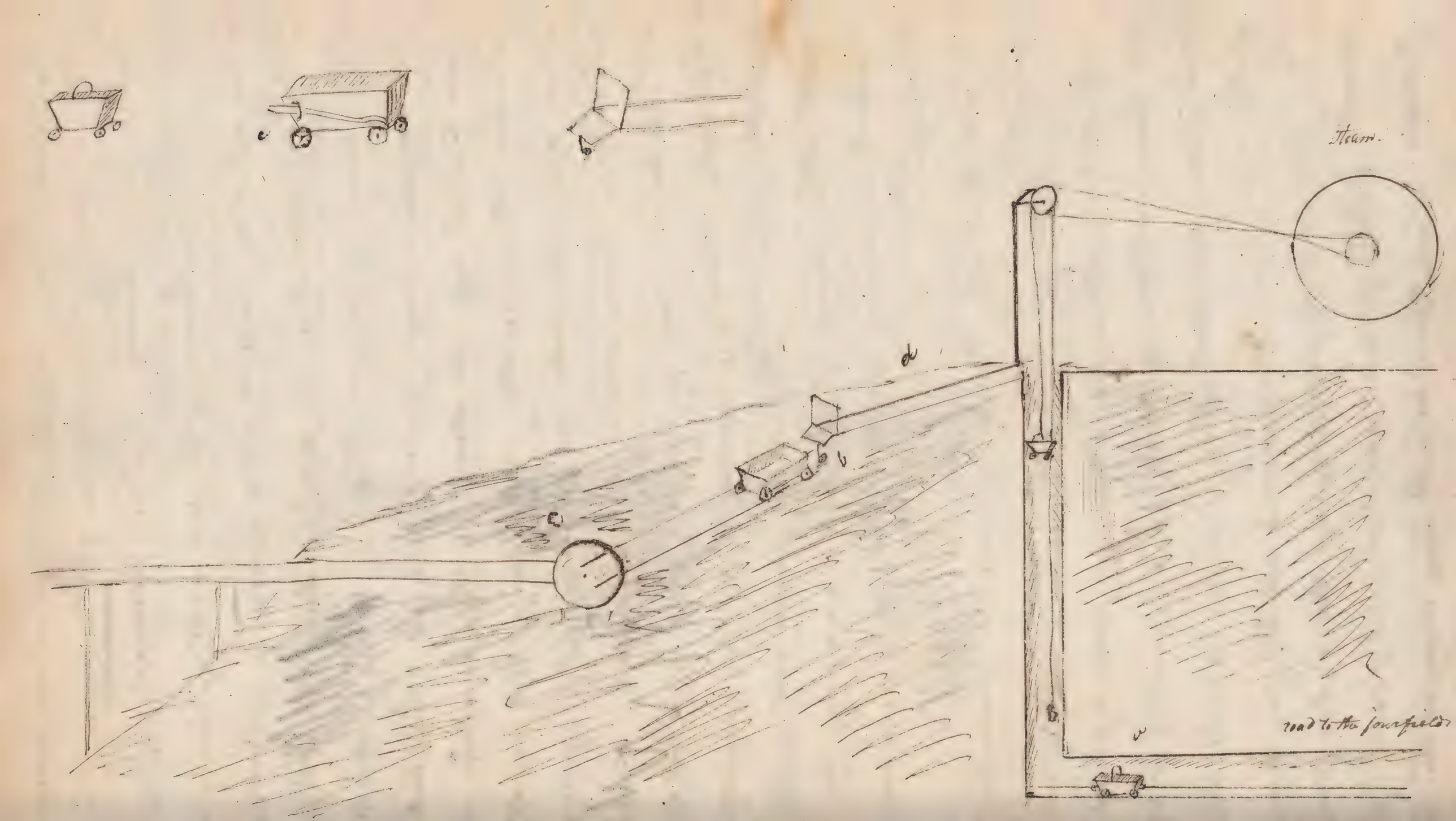
Coal.

Coal, which is a fossile of the utmost utility for fuel, is a black or brown, laminated bituminous substance. It is have good reason to believe that the Newcastle coal pits were work'd by the Romans. Introduced into use at London in 1305 A.D. Great Britain abounds in this production. Newcastle has long been the grand mart for it. In order to discover coal, as it lies in strata they bore into the earth. The strata sometimes rise to the surface of the earth, & below the first there are generally one or two others. In boring they make a large pit, at the bottom of which a man is stationed. Iron rods are moved up and down by a machine above the pit, & there are easily turned by the man at the bottom. The lower rod is made like a scoop, so that a round hole is thus formed. The rods are drawn up by an engine or wheel at the top, and at the bottom is fixed what the colliers call a sludging pit, wh being formd hollow draws up the earth loosend by the boring, & this being examined determines whether they are yet arrived at the stratum.

If they meet with rock in their way the
fasten a chisel at the end, wch by the circular
motion given it form a round hole. If one
of the rods should chance to break, the bottom
one tho frequently of great length, & being
consequently of great weight are raised by letting
down an instrument of considerable weight in
the form of an extinguisher. This fastens so
firmly on the Rod that it is alone sufficient
to raise them. The operation of Boring is ex-
tremely slow. When they have arrived at
one seam of coal & found its thickness, they
bore on till they arrive at a second.
These seams are sometimes 10 or 15 yards
thick. A shaft is driven to the seam, &
the coal is undermined, & thus procured. Some
coal mines run a great way under the sea.
They distinguish the part where they are
at present working by the name of the four-
fields, & the coal is drawn in waggons by
horses to the bottom of the shaft. It is then
raised by means of a steam engine, & descends
down an inclined plane. ~~It~~ emptied into
into a larger waggon in another plane, wch when
full also descends & is conveyed to any place

These waggon ways are carried through many parts of the town at Whitehaven, under buildings, & over the ports. When a ship is to be loaded she lies under the waggon way, & a pipe being taken out of the bottom of the waggon the coal falls thro a pipe & trap door in to the ~~ob~~ vessel.

The coal is brought from the fourfields in small carts a which are drawn upon waggon ways. The carts are hook'd on to a rope & raised by a steam engine something above the mouth of shaft; over the mouth a waggon way is slight & the cart lan-ded. It then runs down the inclined plane (d) by its own weight, till arriving at the bottom the fore part ~~ben~~ running down the steep declivity the ~~waggon~~ cart on sets & empties itself into a large waggon on an incl. plane below. The cart is prevented from falling by a bion wh. catches it, & it recovers its balance by the b (b) wh. is hung above its centre of gravity. When the large waggon is sufficiently filled it descends down its inclined plane till it arrives at the wheel (c) ~~a~~ which being turn'd round it is plac on another inclind plane & so on. On the large wag-gon is a break to prevent it's running too fast. It operates by stopping the fore wheels, wh. it does at the pig (e) is removed.


Steam.
road to the fourfields

Coal mines are subject to great inconvenience from a want of circulation of the air. The means for obtaining wt. have been already recited. The inflammable air will explode even when it has passed thro' water. The colliers often explode it as it rises thro the shaft, there being no danger than as there is a plentiful ~~supply~~ stream of vital air. They take care to prop up the levels as they go along, but besides these & the cohesion of the earth, when ~~the~~ old works are shut up the water wt. collects in them serves as a support. Some old works wt. ran under the town of Whitehaven & had been closed a great length of time, being accidentally opened the water gushed out, & the earth thus losing it supports, gave way by wt. accident many parts of the town were much damaged.

A kind of Tar is extracted from pit coal for wt. there is a patent. The coal is put into ovens, wt. are heated by fires lighted under their bottoms, & the liquid matter is sublimed from the coal thro' a pipe at the top of the oven, wt. is connected with condensers. This tar is us'd for paying the sides of shaft about 5 lbs of tar are extracted from 1 cwt of coals. Lord Dundonald has brought this tar

white &c. Bitumens are either fluid as oil, or tenacious as tar, or solid. The fluid Bitumens are two Naphtha & Petroleum or rock oil. Naphtha is light & inflammable. Petroleum darker, as brown or blackish. These either float on spring water, or drip from crevices of Rocks. Mineral Pitch is thicker, heavier, & more glutinous than Petroleum. Babylon was cemented with it. It is now called Barbadoes Tar. Asphaltum much resembles it. This is thrown up in a liquid form on the Dead Sea. The difference between all these Bitumens lies in the different proportions of acid. Pitcoal, jet &c seem chiefly to consist of petroleum & argillaceous earth. Petroleum seems to arise from animal & vegetable juices in the earth. Besides these there are Jet &c resembles Cannel, but is electric, Amber &c is found chiefly in Prussia though it seems to be formed by exudation of trees, or by an oil arising from the decomposition of vegetables by subterfuse & a mineral acid. It is electric. Ἤλεκτρον.

Ambergris is an animal substance found in the Spermaceti whale, & situated like musk, civit &c.

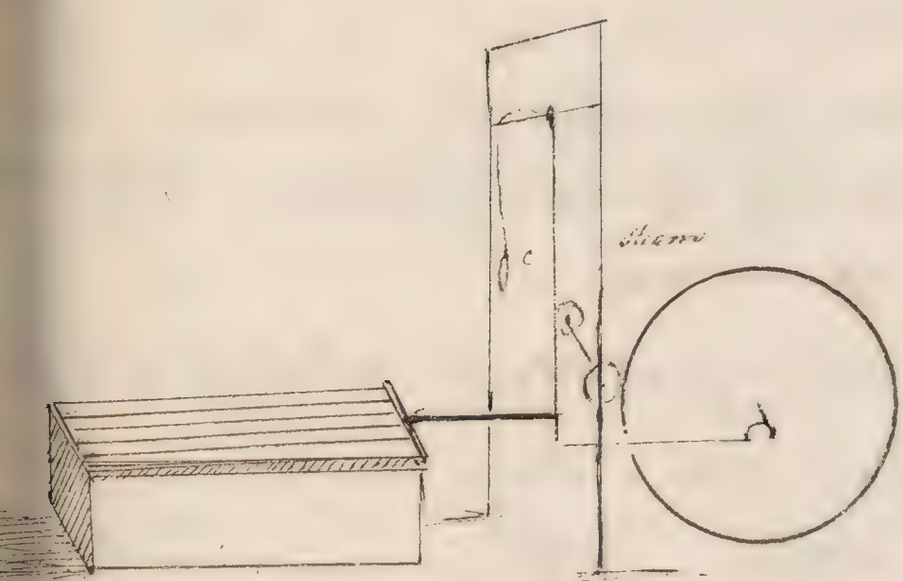
Coak is formed by a distillation of pit coal, (as Charcoal is from wood) when the oily parts are evaporated. - This great use in fluxing iron made at Newcastle & Cambridge

Marble –

Marble and Limestone are of the same nature. They consist of an union of lime and fixd air. marble seems to have been originally in a fluid state, which by pothesis accounts for & is strengthind by the different animals, shells &c found in marble. Black marble seems to have been colored by petroleum. Limestone and marble frequently lie together. Our english marble is chiefly obtaind from Derbyshire. The first operation on a block of marble is sawing. For this purpose it is carried to an engine of this kind ——————

The saws are made of soft iron, & a small quantity of water with sharp sand is insinuated into the furrows the saws make, by means of a weight (c) balancing the saws & they are thus easily raised. The sand by the friction of the saws penetrates the marble & thus greatly forwards the operation.

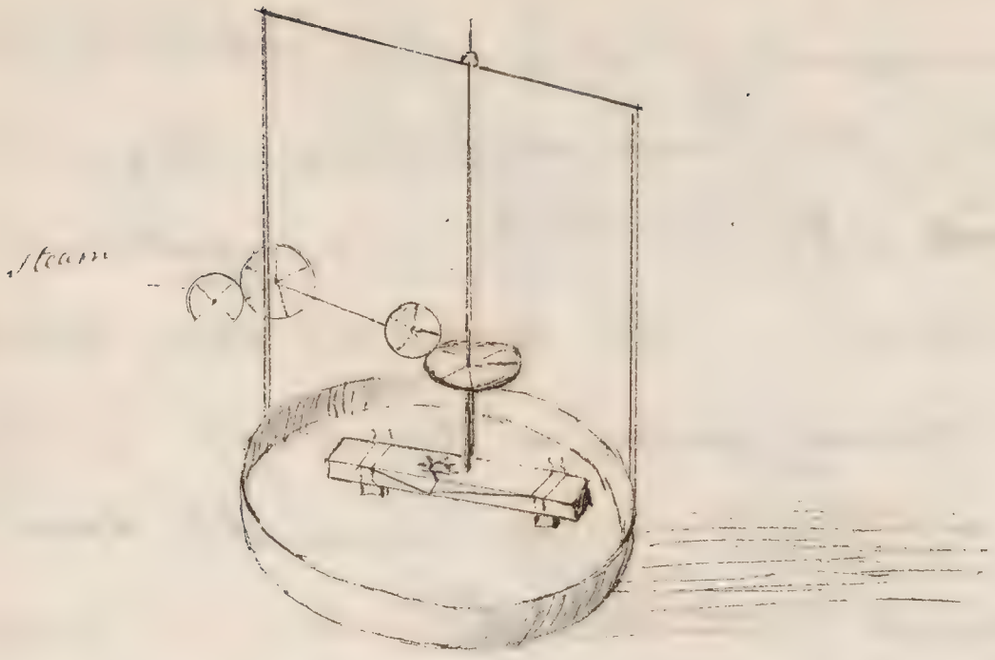
It is then carried to a sweeping mill to have the inequalities on its surface taken off. In this operation the floor is covered with water. The pieces of marble do not only move round at a certain distance from the centre, but

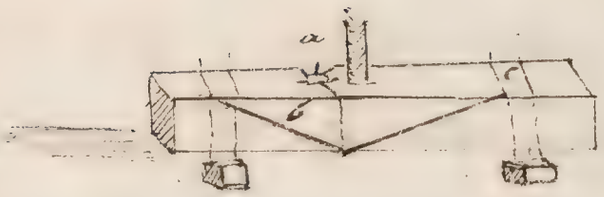

c
Alarm

they have also a motion by wh. one approaches nearer to the centre as the other recedes. The slabs thus pass over the whole surface of the floor and preserve it plane i.e. not worn more in one part than another — The slabs have also a free motion themselves, not being bound tight to the beam — as the beam moves round the small cog wheel (a) is turned, & moves a crank that crank draws the small beams (b) nearer to & farther from the centre alternately, & these beams being connected with (c) by wh. the marbles are fastend, the slabs have also this motion. The slabs are only fastend loosely by threads — The whole machine is turned by steam —

Planes are obtained by rubbing slabs wh. have been swept & have have there surfaces nearly equally plane together. Planes are used for a great number of purposes such as chimney pieces. In order to find whether a surface be plane they use an instrument of this sort — there are screws placd in the ~~bran~~ wood, wh. being exactly of the same length & set accurately even, if the instrument lie even upon the surface, it is a plane —

marble is then polish'd, for wh. purpose they use emery & afterwards putty. Emery is an extremely hard, & refractory mineral containing a little iron. In the polishing machine as well as in


Steam

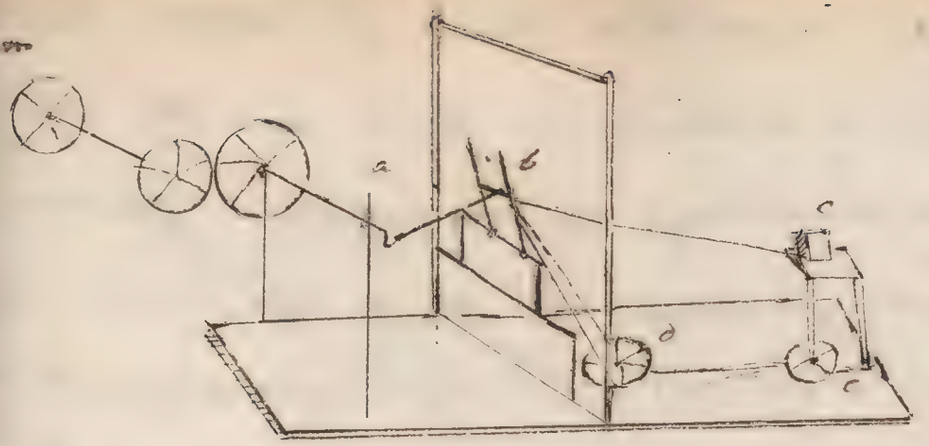

a
c
b

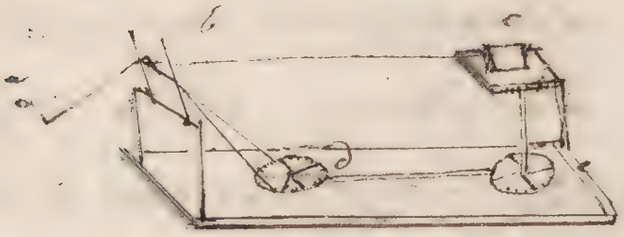
the sweeping mill, it is necessary that the marble should have two different motions to prevent unequal friction. In order to effect this in the polishing machine, the polisher is moved ~~with~~ in a direct line, the marble has a lateral motion. The crank (a) being turn'd by the steam engine's acting on the wheels, it draws backwards & forwards the two moveable bars (b) wh being connected with the polisher (c) move it in a right line upon the marble slab underneath it. To give this slab a lateral motion from the two bars, there proceed two catches to the horizontal wheel (d) so that ~~by~~ the motion of these bars serves to turn the wheel, & this being connected by means of a bar with another horizontal wheel (e) This wheel by ~~its~~ axis a motion to the slab (f). This slab therefore is equally polished in all parts —

There is an insect wh makes holes in marble, by means of an acid wh it casts upon it. This is call'd a Polidee.

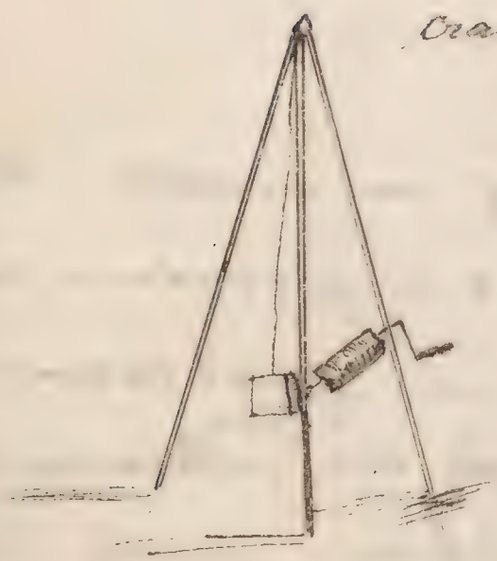
As marble is iss'd for building, it will be ~~just~~ proper just to mention the manner of raising the blocks ~~of stone~~ to the required height.

The general way is by a large ~~prismatic~~ triangular figure to one side of wh a windlass is applied & the stone is rais'd to the top. but this can only be used where the ~~ground~~ space within the ~~prism~~ triangle is clear, to remd





Crane

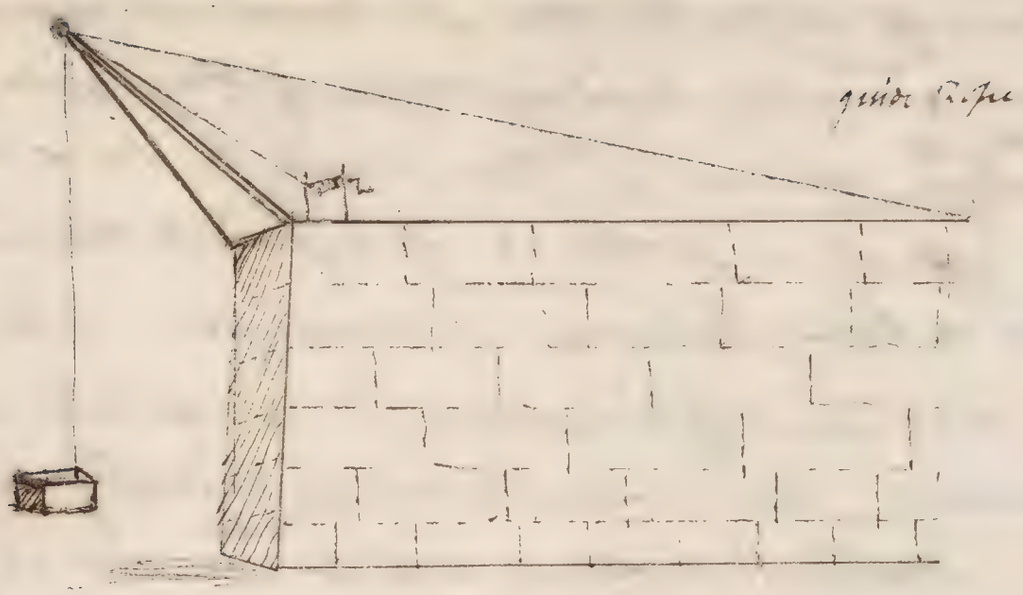


wt inconvenience another kind of crane call'd shears. This machine is fixd on the top of of wall they are building & is inclind downwards but prevented from falling by a guide rope. The stones are then drawn up by a windlass to a height above the wall. The guide rope being tightend the shears are raisd perpendicular & the stone is let down. This kept suspended however till the bed of cement is laid.

In raising stones they use a sort of wedge call'd a lewis. A hole is cut in the side of the stone much wider at the bottom than the top. The lewis is divided into three separate pieces the two outward ones are angular, the inward one plane. They are also ~~wider~~ broadest at the bottom, & tho they will not all go in together, they will go in separately, the wedge not being able to come out the stone may raisd by a rope fastend to a ring at the top of the wedge where there is also a pin to secure the parts together.

Limestone.

Has been partly treated of in marble. When reduced by a kiln to lime it is of great use in cement, in agriculture &c — As it consists of calcareous earth & ~~out~~ fixd air, & water when exposed to continued ignition it gives out nearly half its weight of fixd air & water. The remainder consis



Levers separated

ting chiefly of lime, has a strong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very considerable heat, with noise, and agitation of the parts wh. break asunder. Lime is thus said to be slaked. The same effect is produced if exposed to the moisture of the atmosphere; it crumbles like marl & hence its use in agriculture. Mortar composed of lime & water has a considerable degree of adhesion & ductility. Sand & broken vessels & Hair increase its firmness.

Gypsum or Plaister of Paris consists of ~~lime~~ alabaster united to the Vitriolic acid together with water.

The earth wh. enters into the composition of the bones of animals & shells of fish is calcareous. In the former it is united with phosphoric acid in the latter with fixd air.

Clay

Is of that species of earth call'd argillaceous. Its most remarkable characters are its ~~remarkable~~ tenacity, & ductility when moistened; & its growing hard when exposed to fire. When bakd it entirely loses its tenacity. Clay is intermixd with many heterogeneous particles these for the most part are seperable by washing.

The whitest clays are esteemd the purest alum is ~~composed~~ formd by a mixture of the

In some places as in Cambridgeshire lime is prepared from a calcination of chalk. In Holland fish shells are burnt for lime. In the southern Hemisphere coral rocks are used for the same purpose

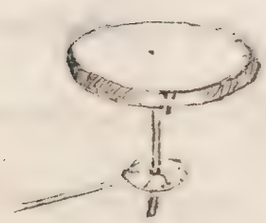
Marles are argillaceous earths mixed with sand & much calcareous earth. They have a crumbly texture.

vitriolic acid, & an argillaceous earth, wh is the reverse of the Gypsum mentiond above — alum is made at Solfatara near Naples by placing little heaps of argillaceous earth over the crevices, whence the sulphureous smoak issues. Now sulphur by combustion forms the vitriolic acid, & this dissolves the clay.

In England alum is made from shale, wh is much impregnated with bitumen. Coal emits a sulphureous acid, as does also shale wh combining with the argillaceous earth of the shale forms alum. 120 tons of calcind shale give 1 ton of alum.

But the most important use of clay is in pottery. all sorts of earthen wares, from the coarsest pots to porcelane, consist either wholly or principally of clay. The variety of the properties of earthen wares depends on the properties of their constituent clays.

When the clay has been tempered, in forming the common ware they throw a ball of it on the centre of a potters wheel, wh is turnd by the foot or hand. By its revolution they form it into any shape with the hand. It is then cut off from the wheel by a wire drawn thro' the bottom. Being a little dried it is put upon a lattice & receives other impressions. It is then thoroughly dried in the air and put into a furnace.



The several pieces of it are put into cases made of clay, called Seggars, wch are piled upon one another in the dome of the furnace, a fire is then lighted & when the ware is brought to a proper temper wch happens in about 18 hours it is glazed by common salt. In order to determine the proper temper they draw out small pieces of porcelain placed in the furnace for that purpose. As the dimensions of pottery are the less, the greater the heat wch the article has been subjected; a thermometer has been constructed for measuring the heat of furnaces, by igniting a small brick of known dimensions therein & afterwards measuring its contraction. Wedgewood was the inventor of this. In glazing with common salt, the salt is thrown in to the furnace thro' holes in the upper part of it, by ye heat of wch it is instantly converted into a thick vapour, wch circulating thro the furnace enters every Segg as thro holes made in its side & attaching itself to the surface of the ware it forms that vitreous coat called its glaze. This method was introduced from Holland abt 80 years ago. In giving the yellow glaze to the queens ware 112 lbs of white lead, 24 lbs of ground flint & 6 lbs of ground flint glass are mixd together in water. The ware having been baked, it strongly imbibes moisture, it is therefore dipped into the mixture of liquid glazes & suddenly taken out, the glaze is imbibed into the

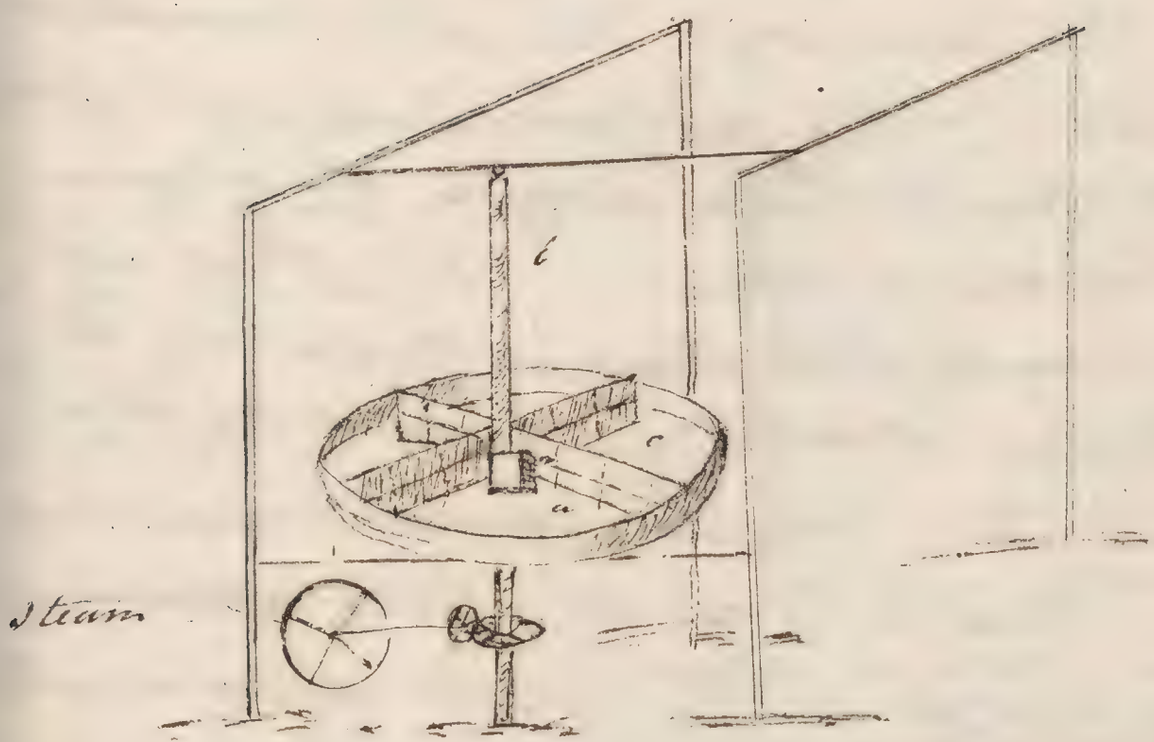
Furnace for baking China -

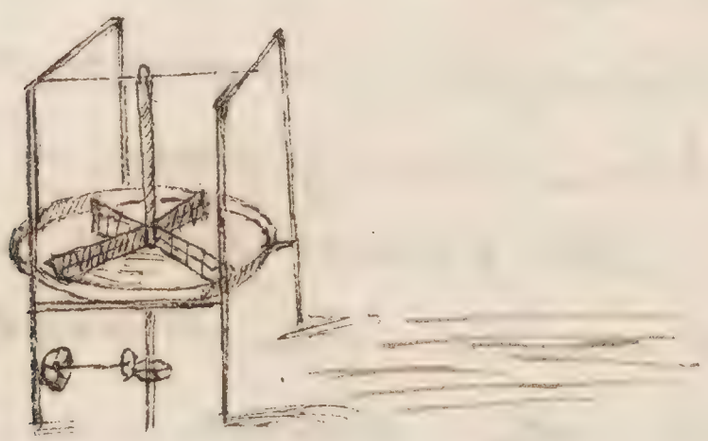
a/ grates b/ chimney c/ Dome at the bottom of wh is
a grate x floor on wh the seggars are placed

pores & the ware soon becomes dry; it is then again exposed to the fire & the glaze is melted & a thin glassy coat is formd upon the surface. This more or less yellow according as a greater proportion of lead has been used. Litharge is usd in glazing, for lead of all substances known has the greatest power of promoting vitrifaction. The flint gives a consistency to the glaze. The yellow colour may be wholly changd by a small addition of ~~man~~ other mineral substances. A beautiful black is given it, by a mixing 21 pts of white lead, 5 of powdered flints, & 3 of Manganese an earthy or metallic mineral.

In making fine ware they mix powdered flints with the ingredients. For this purpose the flints are heated in order to render them friable; they are then reduced to powder in a mill turnd by steam. The heated flints are put into the circular place (a) in which the upright pole moves round by the force of a steam engine. To this upright pole are joind the flaps (c) wh accordingly have the same motion. Now between each of these flaps there are two large stones, wh will by their motion reduce the flints put between them into powder. After this grinding the flints are put into water, & the finer parts floating, when the water is let off thro' an opening near the top these fine parts are carried off with it, this fine powder is then put into kilns & when dry is mixd with the clay. The cups are baked and painted before they are glazed. Or the colors

Grinding Mill





being composed of the calxes of metals bruised & incorporated with very fusible glass, are applied. These cups having been glazd once is then heated again & the colours not only stick but have same consistence with the other glazing. or before the cup is glazed they impress a piece of paper & while it is wet they put it on the cup & the impression being left. the cup is glazd as before. Cups are gilded either by applying the gold in powder mixd with glass as they do colors, or by making an amalgam & evaporating the mercury. The gold is burnished with a bloodstone. The fine porcelaines will strike fire with flint. This is owing to the siliceous particles contained in them. The flint used is chiefly brought from Kent. In grinding the flint they use Chert wh. is itself a sort of flint. The coarsest wares are made with Tobacco pipe clay & sand. Dresden & asiatic China unvitrifiable. The materials of wh. the asiatic china is composed are Petuntse a vitrescent stony substance reduced to an impalpable powder, and Kaolin an unvitrifiable unctuous clay, & of a varnish of the consistence of cream in wh. the vessels are dipped. The granite found in Cornwall is thought to resemble the Petuntse, and the soap rock the Kaolin.

The Porcelaine when baked & not glazed is called buiscuit & images &c are left in a state of buiscuit. The manufacture at Sèvres excels in this

clay is used in making bricks — They were introduced into England by alfred ye great. The contraction by burning is various according to the species of clay —

Modelling.

The impression model is formed by giving white wax the form required. It is the only difficult part of the operation, & is performed by persons well acquainted with the wax. The model is nicely touched over with linseed oil & plaister of Paris or something of that nature is then poured on. This will serve as a mould to another model in the same plaister. On this moulds may be cast in metals. & thus the first impression may be continued —

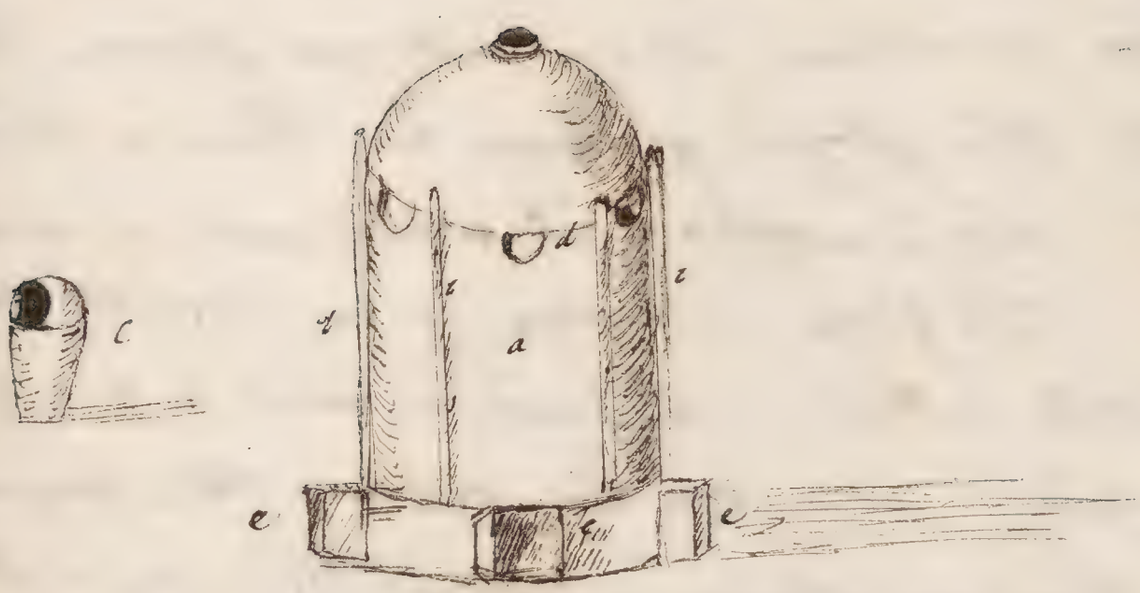
Flint.

Is of that class of earths termd siliceous. Have the property of striking fire with Iron, also by a percussion agst another piece of flint, the last fire is however internal, depending on Electricity. It is decompos'd by air. Dissolv'd by alkalies. By the action of Alkali upon siliceous earth glass is formd. For this purpose, nothing more is necessary than to expose a proper mixture of sand, flint, or crystal, & fixed alkali to heat in a furnace till they are uncompounded by fusion. If the materials be impure the glass will be colored or defaced with flake specks. If the proportion of alkali exceed two parts to one of earth the glass will be liable to alteration from the air, salts, & especially acids. The different sorts of glass depend upon the purity of the materials. The common green glass is made with merely river sand & alkali. Near Lynn there are pits of fine white siliceous sand, much us'd in glass making. There also pits of the same sand in the Isle of Wight. There substances viz the alkali & siliceous earth, are ground & fitted into a furnace, but to prevent their swelling at the first combination, they are exposed to a lower heat than is sufficient to convert them into glass, by wch mean the more volatile parts are dissipated. This imperfect combination is

called frits, & it is afterwards fused in a strong er heat. An exceedingly strong heat is required; when the materials are heated they bubble up.
In flint glass lead is added to facilitate the vitrifaction, but as the phlogiston contained in lead causes the glass to be coloured, manganese is added to render the glass achromatic. The finer sorts of glass called Crown glass has no lead in it, or very little to render it less brittle. Glauber's salts & vitriolated Tartar are used instead of Alkali. The two kinds of glass Flint & Crown are sometime combined together in making lenses. Dollond's glasses are of this sort & are achromatic.

The glass is materials to be fused are put into a crucible entirely close except the mouth which is on one side & answers to an opening in the furnace, by this means the glass is kept entirely free from smoak. The mouth is however closed, unless it be necessary to examine the state of fusion. There are cellars under the grate of the furnace to determine the draught. By these cellars it is that the glass furnaces are capable of giving a greater degree of heat than any others. To make the heat circulate equally there are flues on each side the furnace.
The glass is rolled when melted on the end of an Iron tube & blown. It should be kept in fusion for ten or twelve hours. Glass is some

Glass furnace



a / the dome under which the fire & at the bottom get a grate
b / flews / c / crucible / d / mouther to which the crucible
is applied e / cellar

In the uppermost division is a chimney from the
second one. In this upper apartment glass is some-
times fritted to be annealed.

times moulded. In forming the glass into a particular shape they turn the tube on the iron arms of a chair with they call, & give the required form by an instrument call'd pincers. To make a neck to a bottle the globe of glass & shield round with the tube & then draws it out into a neck.

To make glass cylinders two workmen take hold of the globe of glass which they run with it different ways. as the glass is thus drawn out it grows thinner in the middle & cools very soon, & retains its cylindrical form. To prevent the glass growing too thin in the middle air is wafted on it which cools it very soon. The glass is broken off by slightly touching it with cold water in the part required to be cut off.

Plate glass is made by casting the largest globes that can blown, & rolling them on a plane surface — Or the glass being melted in crucibles is spread whilst liquid upon a table covered with a sheet of copper, in the same manner as plumbers cast their sheet lead. The plate of glass when first cast is smooth in texture; its asperities are ground away with coarse grit stone, sand, & emery, & is at last polished with colcothar i.e. the earth remaining from a distillation of vitriol. This method is practised at Paris on the glass that come from Picardy —

persillers

Looking glasses are silvered by an amalgam of tin & mercury. Tin may be beat out into leaves not thicker than paper called foils; on tin foil laid on a flat table quicksilver is poured & rubbed gently with a hare's foot. It soon unites with the tin & then becomes very splendid; a plate of glass is then slided upon the tin leaf in such a manner as to sweep off the redundant quicksilver, & is not incorporated with the tin: Leaden weights are then placed on the glass; & in a little time the quicksilved tinfoil adheres so strongly to the glass, that the weight may be removed without any danger of its falling off.

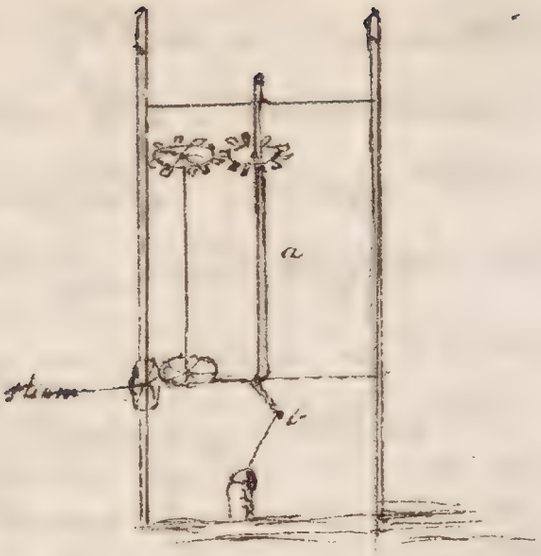
All glass utensils unless very small require to be annealed. This operation is necessary to prevent their cracking by change of temperature, by the contact of sand or flint, or slight accidental scratches. For this purpose they are put into an oven when cold blown & are cooled very gradually. It is generally done in three days or cooling.

Lenses are formed by moulding. They are either - plano-convex - plano-concave or convexo-convex - i.e menisci or watch glasses.

When cast they are ground with sand & afterwards with emery - polished with putty and pitch. This is often done with the hand with a little hollow instrument which exactly answers to the lens - but more frequently that instrument being of a larger size, is turned by steam & ground down several lenses which are placed on a convex surface exactly

answering it. The axis (a) being turn'd it moves the crank (b) & thus gives the little instrument a motion wh is not merely circular but wh causes the instrument to pass over every part of the convex surface. on this are several lenses placed & this motion causes them all to be ground equally

When lenses are ground it is necessary that they should be centred; that the rays may come direct. For this purpose they are placed in a lathe in wh is a sort of perspective glass, & it is found by this means whether the center describe a circle or not; if it does the lens is not true.


a
b

Nitre. Sulphur.—

Sulphur consists of Vitriolic acid & phlogiston — It is united to the most substances. It abounds where metallic minerals exist. Sulphur almost pure, called Native Sulphur is found in Volcanoes & grottoes where it is sublimed in yellow transparent crystals. But the greatest quantity we have exists naturally in combined with metals in ores & especially pyrites. As Sulphur is fusible & volatile it is procured from these minerals by distillation & sublimation. When sublimed it is called flowers of Sulphur. It is generally separated from ores during their torrefaction. It is often chiefly imported from the Etna

In making vitriolic acid from Sulphur the Sulphur is put into a furnace in a crucible inverted in a vessel of water, a little nitre being added to give a supply of vital air, the fumes which arise are imbibed by the water, which is put into a retort & distilled ye vitriolic acid.

Sulphur is used in ye making gunpowder, & is combined with nitre & charcoal —

Sulphur is sometimes mixed with arsenic

Nitre is procured in great abundance from the East Indies. The method of making saltpetre there is this. Trenches are dug & when filled with the salt earth, the salted ground that has been taken for sometime they pour in water, & when they judge that it has dissolved all the earth, they draw it off into another trench, & when it is thickened they boil

it like salt & scumming it. they put it into an earthen pot where the dregs being settled they take it out & dry it in ye sun. another way of great obtaining nitre in ye East Indies is this. a large quantity of all grass being burnt in Autumn for beds of very large extent are found covered with such salts & earths as are the most proper matrices for the formation of it here. these lying all winter exposd to the winds collect the nitrous spirit from the air & produce great quantities of Nitre. the ensuing rainy season washes the salt down into the valleys where by the heat of the sun the salt is left in a dry state. In Patna it is extracted in the greatest abundance from a whitish black or red clay. this is diluted with a quantity of water wch water being boild ~~in water~~ yields ~~the best~~ saltpetre superior to any found any where else. Nitre in the East Indies is extracted from the earth, but with us it is obtained from any putrefying substances, from earth where the putrefying substances are lodgd & wch are grown mellow, from old walls where it shoots in crystals, & from whence it has and its name Saltpetre. Great attention was formerly paid to the procuring it in England, but all attempts have failed as it is procured at a much cheaper rate from the East Indies. The dearness & labour of wood ashes (used in purifying it & uniting it with alcaline basis) have rendered all attempts ineffectual. It is now procured but in substances that have

undergone a putrefactive fermentation.

In Spain saltpetre is extracted in large quantities from earths naturally impregnated with it. A third part of the uncultivated lands in Spain are said to abound with saltpetre ready formed. These lands are turned over two or three times in the winter & spring, & in august the saltpetre is extracted by pouring water on the earths & crystallizing the solution. The earth is spread again & at the expiration of 12 months it again becomes impregnated with saltpetre. saltpetre consists of nitrous acid & vegetable alkali; & may be produced by a mixture of these two substances. Potash may be made into nitre by aqua fortis, & this kind must never be exported to any enemy who has potash but not saltpetre.

Nitrous acid is composed of azotic air & vital air. Nitre will burn in a situation where nothing else will, for tho' there be no supply of air for supporting the flame from without, the vital air it contains itself will be sufficient for the purpose

Gunpowder

Is made by combination of 9 pts of sulphur 75 of nitre, 15 ½ of charcoal. The proportions indeed differ according to the strength of the powder. The two principal ingredients are the nitre & charcoal, the sulphur only serving to inflame it. The parts are reduced to a fine

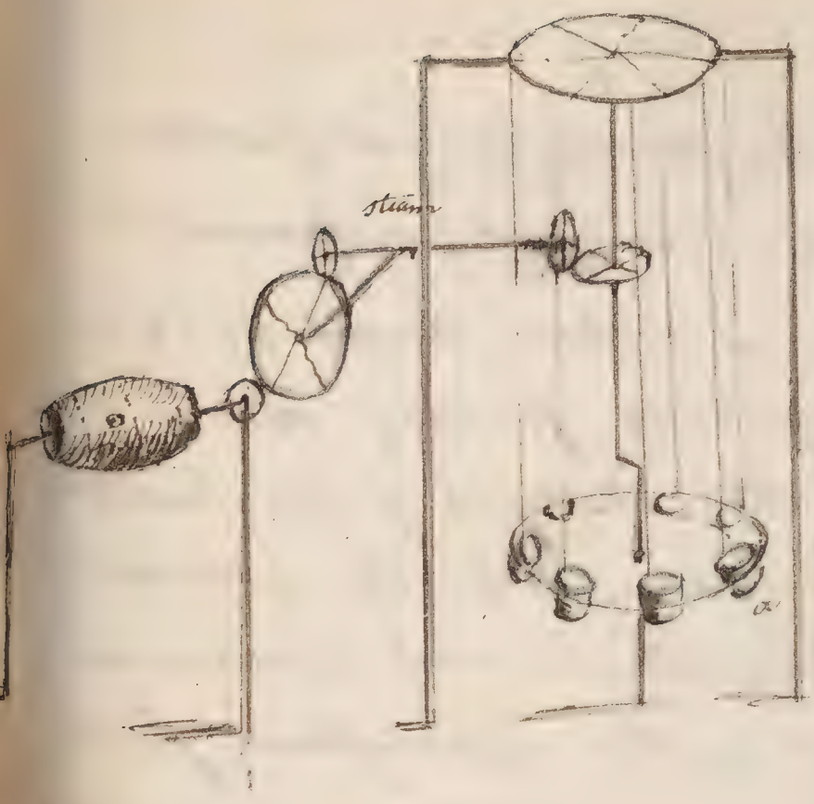
powder & intimately mixd with one another. For this purpose they are put into large wooden mortars with a little water — but as it is necessary the powder should be of a large size than these fine particles, it is put while wet into a granulating mill.

The whole is turnd by steam & the powder is put into small boxes at the bottom of wh is a parchment with holes in it of the required size. beneath this is a gauze wh will let the dust pass thro' but retain the grains. a weight is then put over the powder & by the motion of the machine & the weight above the powder is forced thro' the holes. The boxes have not a truly circular motion, but a crank (a) gives them a very irregular one. This motion facilitates the operation.

It is then glazed & for that purpose it is put into a barrel, wh being turnd by steam engine rubs the grains against one another & gives them a polish —

The detonation of gunpowder is caused by the expansion of the fixd air formd by ye nitre & charcoal. If gunpowder be wetted the nitre is dissolved & the intimate mixture of the parts destroyed. It is this that spoils the powder. If common salt be mixd with ye saltpetre it attracts moisture & injures the powder

Granulating mill.

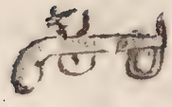


a) Boxes in wh. ye powder is put, wh. by means of their connexion with the upper wheel by threads have a very irregular motion.

Battle Gunpowder is the strongest

Barrel powder is very coarse.

In order to estimate the force of Gunpowder they put a little into a small instrument resembling a pistol. A valve kept tight by a strong graduated spring firmly closes the mouth of the barrel & the strength of the powder is determined by the distance to which the spring is forced back. They also prove by a cannon of very small size, & by the repercussive force of the powder lengthen a graduated measure along


spring valve

Salt.

Common salt is a neutral, consisting of the mineral alkali & the marine acid. It is distinguished into fossile or Rock salt spring salt — sea salt.

It is obtained from sea water by Evaporation. In England a brine composed of sea water, with the addition of a little Rock salt, is put into large shallow boilers & evaporated. The crystals of salt are taken out in baskets. These pans are of different depths & the water is evaporated in much ~~larger~~ greater quantities the ~~gre~~ larger the surface expand to the atmosphere. It is baled into the shallower pans. The pans are healed gradually & just before the brine boils whitening & butter are put in to make it granulate. The greater the heat the smaller is the grain of the salt the weaker. The salt is formd at the top but sinks & is raked out. A bitter substance called mother water containing magnesian salt remains which is made into Epsom salt & Glauber's salt. Epsom salt consists of vitriolic acid & magnesian earth & is formd by boiling & cooling it very quickly. Glauber's salt consists of vitriolic acid & an alkali. It is boiled for a very short time & put into large vessels where no cold air being able to enter, it cools

gradually - In the north of Europe the
sea water is exposed to freeze & the ice wh is al-
most fresh being taken out the remaining brine
becomes much stronger & is evaporated by boiling
In the southern parts of Europe they take ad-
vantage of spontaneous evaporation. A mar-
shy spot of ground is selected communicating
by sluices with the sea & in it they form
pits of small but different depths. The
sea is let in the first & deepest pit from wh
it flows slowly so as to give the mud & sand
time to settle, thro the second into the third
where by the heat of the sun it is converted
into strong brine. This being further evaporated
by the sun concretes into crystals wh gradually
sink. This salt is called bay salt. A great
quantity of salt is formed in the manner by
nature in Rocks &c wh are washed by the sea.
The crystals of common salt are every regular
cubes.

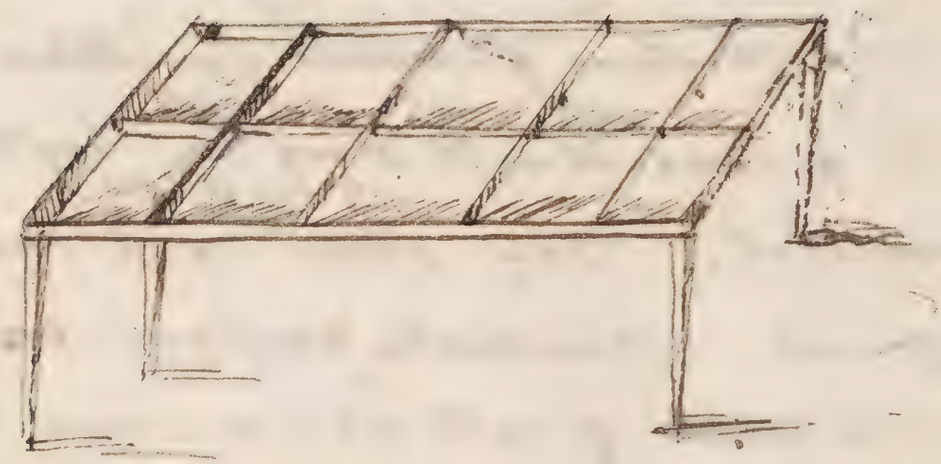
Salt is extracted from brine pits or springs,
wh are met with both above & below the level of
the Northwich bed of Rock salt & are strongly im-
pregnated with salt. They are formed by the rain
waters sinking & dissolving the rock salt.
A great quantity of rock salt is used in strength-
ening these brine springs.

The brine is pumped up into a deep cistern by a mill. It is at first muddy; but after standing some time a number of small insects called brine worms appear in it & after continuing there a short time subside & the brine is perfectly clear. It is then boiled in shallow pans as before. In order bale it from one compartment to another they use a ladle with an aperture & valve at the bottom. Placing it therefore in the liquid the valve is forced up & the fluid rushes in & keeps the valve by its own down.

The rock or fossile salt is found in great quantities at Northwich in Cheshire; in Poland; & in Spain. Much of that at Northwich is used for strengthening the brine springs & a much greater quantity is sent to Liverpool & other places. It is exported free from y salt duty. It is never used in its crude state — but is previously refined into white salt i.e. dissolved in water and boiled down. The advantage of mixing rock salt with the brine springs arises from the same quantity of fuel being able by this means to form so much greater a quantity of salt.

This Rock salt lies in strata. At Northwich there are two strata. The first is about 60 fathoms from the surface. The other 100 fathoms

baler



boiling pans

one i abt 10 feet thick. They frequently
meet with springs of freshwater in the Rock
salt mines, but are enabled to avoid them by
the noise they always hear. The Northwich
workmen pretend that there is a subterranean
River there, wch they call Roaring Meg.
The great inconvenience of those springs is their
dissolving the salt & thus drowning the mine.
Salt is a very good manure for land in small
quantities, but a profusion to vegetables in large
ones. The Cheshire farmers purchase there
fore salt & mix it with dung. They buy it at
1s 6d a bushel. They strew rock salt over
rushy ground, wch entirely destroys every vege-
table. The virtue of salt as a manure arises from
its reducing dead vegetables into an oily putrid mass,
& thus affording nutriment to the living ones. But when
used in large quantities it preserves them from
corruption. It is the property of salt to facilitate
putrefaction when used in small quantities both
in animal & vegetable substances, but to pre-
vent it when used in large. Hence its
utility in our food. A grand use that
is made of salt in this way is in the fish
Bay salt is generally used. Shivery salt is
a salt produced in the same way as other salt, but
by a very gradual heat. It has larger crystals & is
stronger than the salts produced with greater heat

II

Farish's Lectures on the Manufactures — —

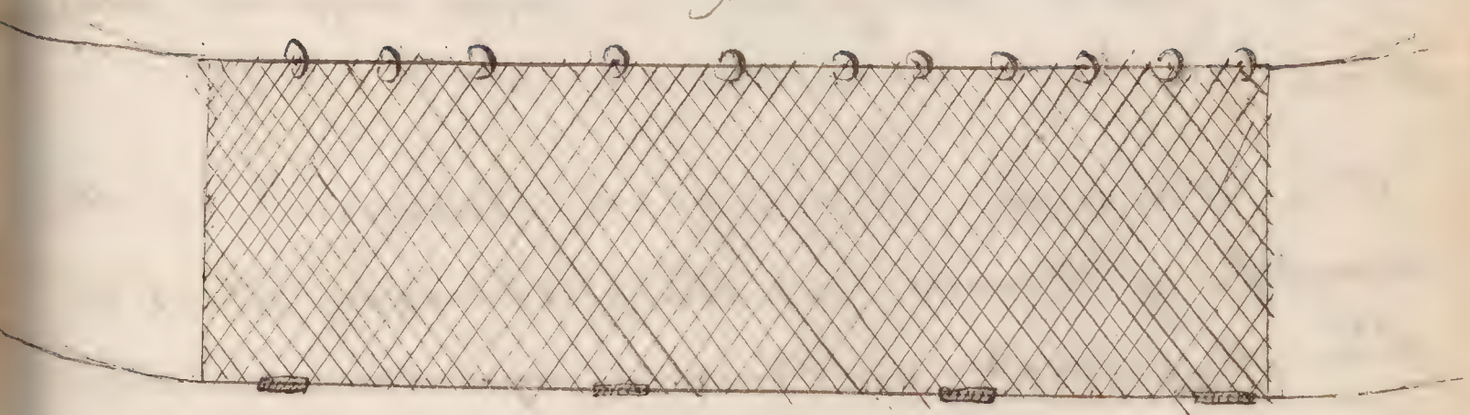
Vol. 3. ——

Fisheries.

The principal fisheries are the Herring Salmon — Cod — & Whale

The Herring Fishery is carried on in boats — The Herrings breed in the Northern seas under the ice & come in large shoals into the more southern parts. There are very large shoals which visit almost every coast of Great Britain. Scotland is particularly celebrated for its fisheries. The Eastern side coast of England abounds with Herrings, but the Dutch have almost monopolized the whole fishery. The Fishermen go out in smacks provided with nets which are loaded at the bottom line & have corks at the upper one, so that they swim perpendicularly. The meshes of these nets are just large enough to admit a Herring's head; — the net being let down amongst a shoal the herrings run against it & stick by the head they are a very tender fish & die almost immediately. They are then salted &c. The Dutch are particularly famous for salting Herrings —

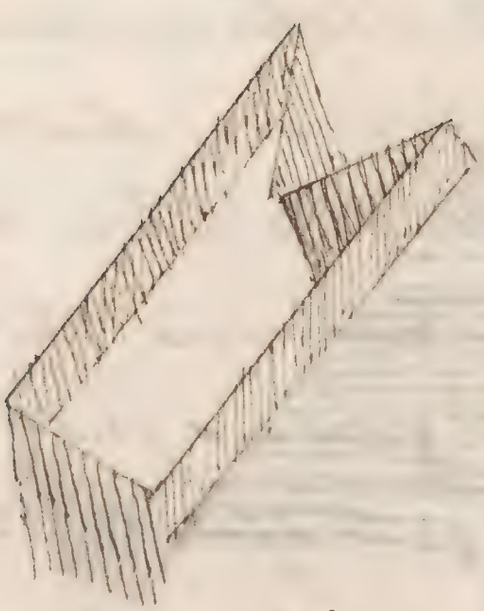
Herring net

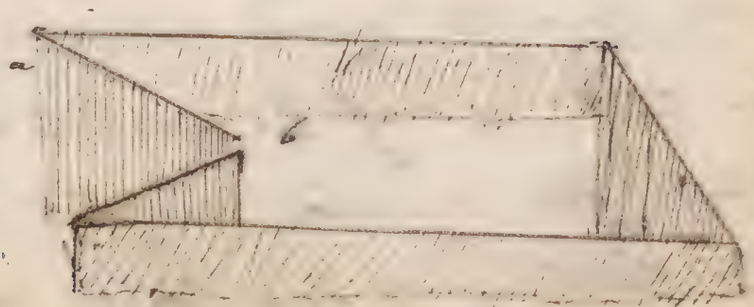


Swims in this situation —

The Cod Fishery is carried on at Newfoundland. The shallops fish upon the Edge - the ships upon the Bank. The men go out in shallops & let out lines baited with herrings. The cod taking them very greedily the men have for some time very hard labour. The fish are then taken to land, where they are opened and spread upon the bark of trees. They are then salted, & thrown indiscriminately into the hold of the vessel. They are afterwards barrelled & carried to Spain and Portugal where they are in great request during Lent.

The Salmon Fishery is pursued in the mouths of Rivers; as the Salmon, tho' it is a fish that breeds in Rivers but lives in the Sea comes every year up the rivers to spawn. The large fish are taken as they go up the Rivers before they have spawned as after they are entirely out of season. They are caught by common nets and boats - but the more usual way is by coops. There are constructed in ye Rivers something in the manner of a trap. The fish swimming up the River gets between the two cheeks (a) & is thus conducted to the aperture (b) thro' which it passes into the coop, but cannot proceed on account of the




a
b

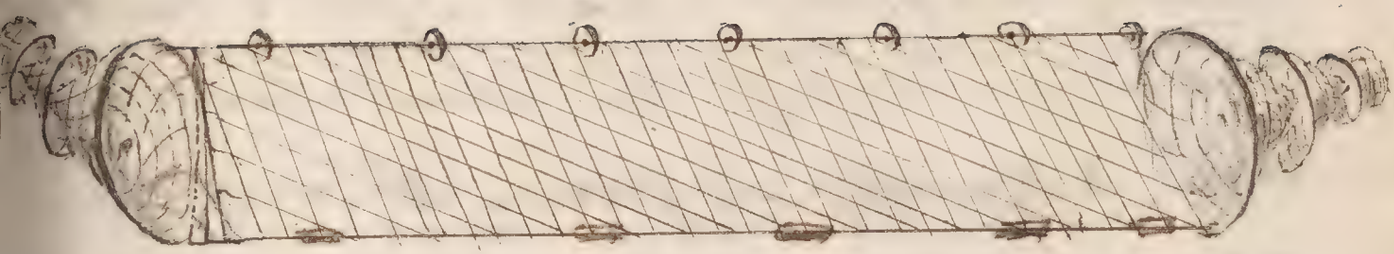
grate at the other end. Nor yet if it endeavor to get back is it scarcely possible for it to find its right passage, & indeed in some coops they have double checks to prevent the possibility of the fishes escape.

Another way of taking Salmon is by laying a net across a river with two Hoop nets at each end. The fish strike against the net and in avoiding it pass into the Hoop nets.

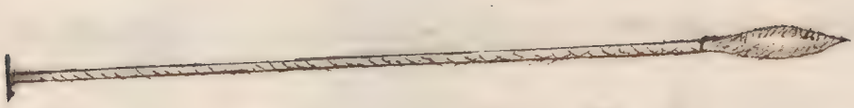
The Salmon leaps to a very great height. It effects this by curling itself up & giving a spring

The Whale Fishery

Whales are found both in the Northern and Southern oceans in the highest degrees of latitude. None are ever found near the Equator. The Fishermen set sail in April and begin to catch Whales near Greenland in May. The fish are discovered by their spouting out water thro' their nostrils. As soon as a Whale is discovered, the men who are sent out to search give a signal and immediately all hands go to work. They generally take care to avoid coming either near his head or tail. as if he were to see them in his sinking the suction might overwhelm the boat; or the lashing of his tail overset them. They



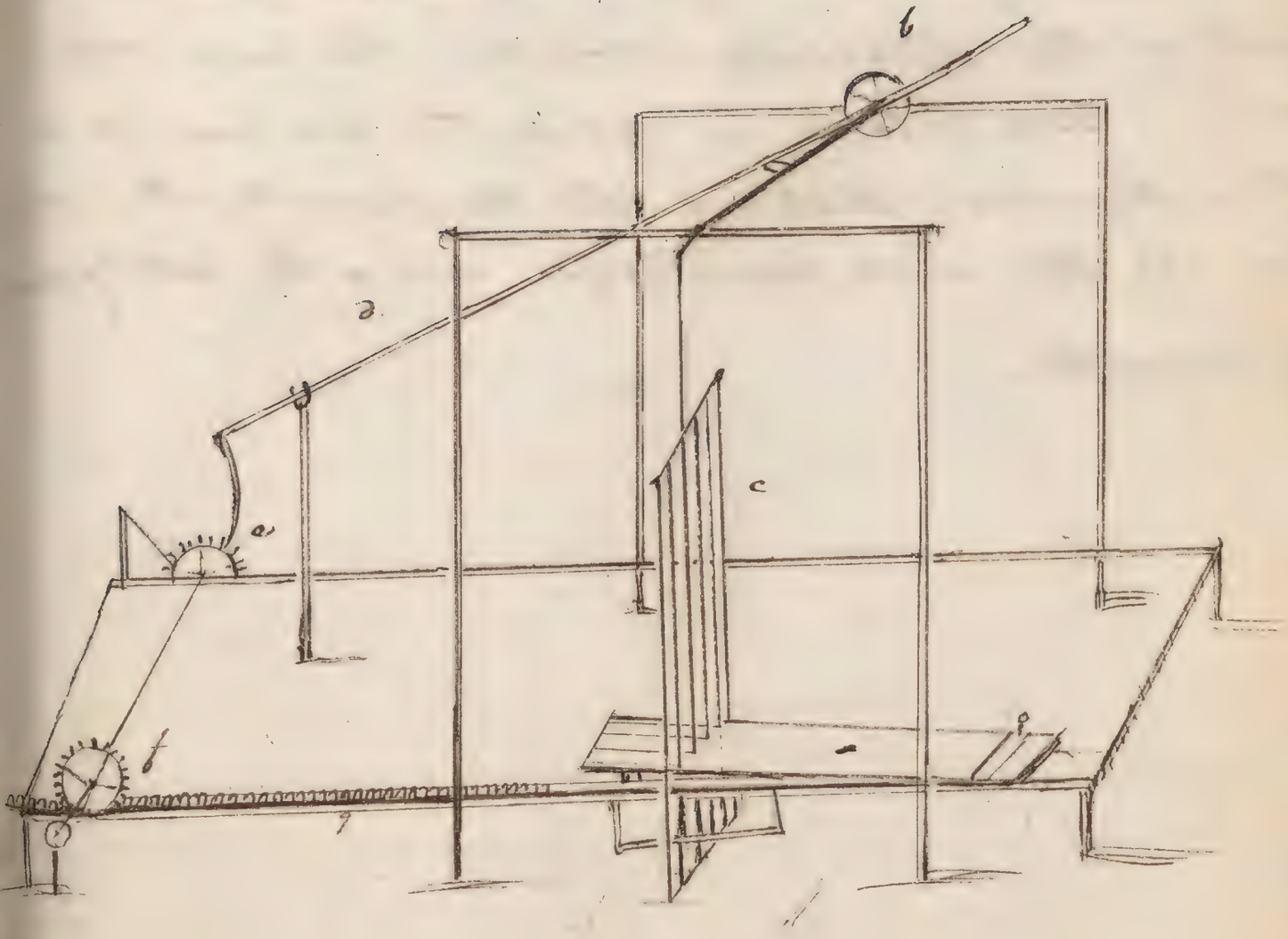
get behind the fish on his back so prevents his seeing them. They strike him from the The Harpooner standing on the end of the boat thrusts his weapon in the fish. It penetrates very readily when the whale is fat & the skin on full tension, but if the skin be loose they have some difficulty in forcing the weapon in. The right hand is placed on the top of the weapon so as to guide force, the left merely guides. The harpoon is generally of this form, but they have a harpoon the barbs of which shut on being thrust in, but expand when the rope tightens. This is called the winged harpoon. On being wounded the whale darts down & carries the boat forward at the rate of 8 or 10 miles an hour. A supply of rope is procured by each boat contributing their allotment & lest the swift rasp of the motion should fire the boat water is constantly thrown over the rope. The whale continues at the bottom some minutes, but on his coming up to breathe another harpoon is forced in. He is also wounded about the more vital parts with lances. They kill him in a short time. When much wounded he spouts up blood with the water thro' his nostrils. When dead they get the harpoons out & lash him to the side of the vessel. They then proceed to cut off the fat and blubber. Those themselves the hold of the vessel stow them & barrel them



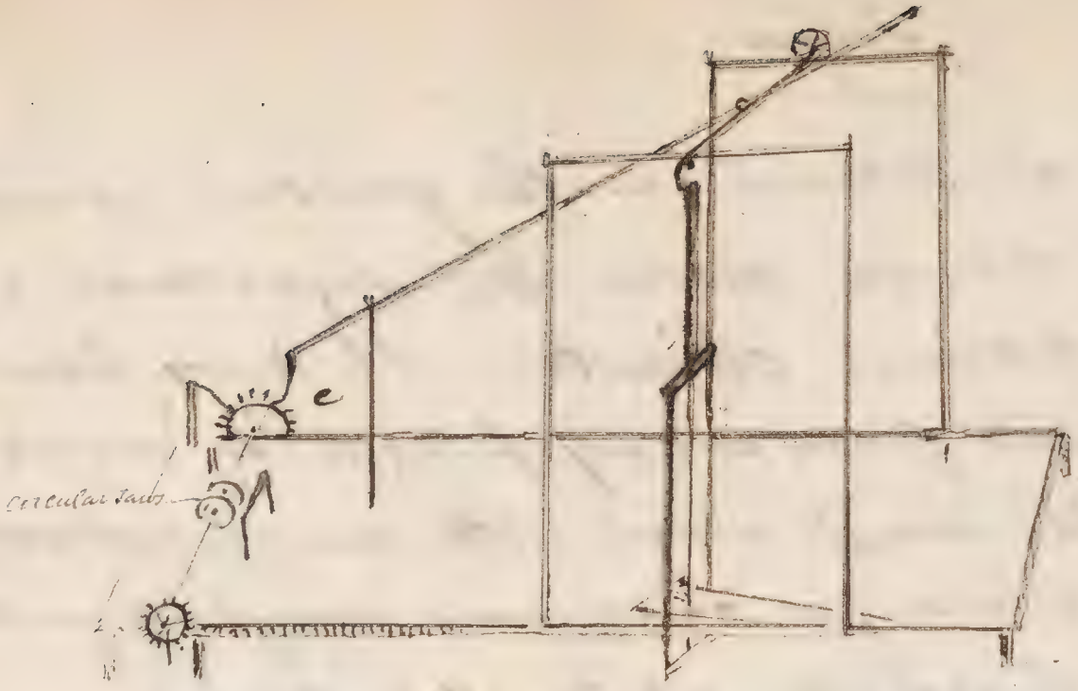
The blubber lies on the surface. The liver contains much oil. The palate forms the whalebone. The jawbones contain oil. They are lashed to the mast of the vessel and the oil run outinto a tub. This oil is the perquesite of the Captain of the Ship. Blubber is generally boild at home, but sometimes at Greenland. It is well washed with water & upon boiling gives train oil. The body of the fish is left to float on the water being no further serviceable. Oil is also procured from Seals, Sea Horses & the livers of Codfish.

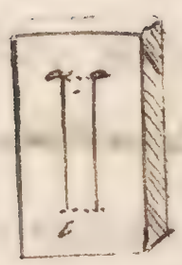
Wood

The most curious operation in preparing wood for use is the Sawing. They generally use the common sawpit &c but there is another machine for the purpose —
(a) the piece of wood to be sawd. Motion is given to the wheel (b) by a watermill or some other engine. The axis is therefore turnd & by means of a crank raises up & down the saw (c). On the axis is a protuberance &c on turning round raises up the long beam (d). Now at the end of the beam is a crank &c being raised turns round a tooth wheel (e) & consequently the axis & the other tooth wheel (f), There is another crank to prevent the wheel (b) from turning back &c


b
a
c
e
f
g
d

The Tooth wheel (f) being turnd drawn forward the bar (g) the teeth of which fit the wheel. This bar is that to wch the wood to be sawd (a) is bound, & consequently this is drawn forward. The two motions of the saws viz up & down & the wood being drawn forward to meet them produce the effect required. as it is of great importance to prepare the block for the pullies on board ships with expedition this machine is used for the purpose. The motion being communicated as before to the tooth wheel (e) the axis is turnd. Upon this axis are two circular saws wch have the same motion. The block required to be sawd is applied close to these & secured with screws tighter as is requisite. The saws make two holes thro' the wood of the required length, & the wood at the extremity being cut the piece drops out. The Block is cut in the two lines (a a) the extremities, that yet hold the pieces together being cut (b) the whole piece drops out & the pully may be inserted.

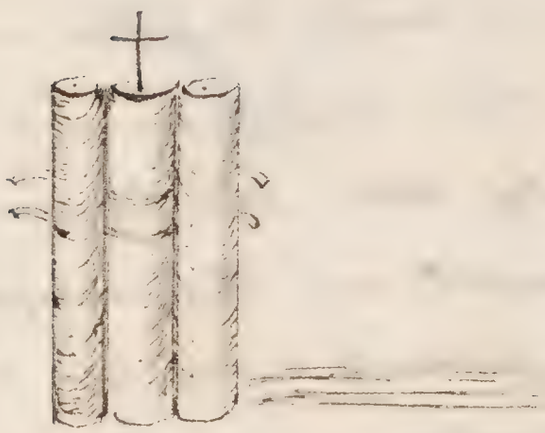

e
Circular saw


c

Sugar.

Sugar is obtained in the greatest abundance from a cane called the sugar cane wh grows in the warm climates. It may however be obtained from many plants in our own country tho' mixd indeed with much extraneous matter. The sugar cane was brought from the East Indies to our West India Islands.

In extracting the juice from these canes, they are put into a mill formd of three cylinders closely pressed together. The middle cylinder is turnd and the canes passd thro' two of them, ~~[illegible]~~ the middle one & that on the left hand — turnd round the middle one and passd again between the middle cylinder & that on the right hand. These cylinders are placed perpendicularly. The fluid wh is thick and tenacious is boiled together with lime & alum & is afterwards suffered to crystallize by standing in a vessel, in the bottom of wh are holes imperfectly stoppd up in order that the syrup may drain off. This syrup is calld melasses. The use of the lime is that the superabundant acid of the sugar wh would prevent its crystallization may be thus drawn off; as this acid has the greatest affinity to lime of any substance. The coarse sugar thus produced is called muscovado sugar. It is imported into England in this state



The Melasses still remain in some quantity in this sugar, & it is the business of the Sugar Bakers to expell them entirely. This operation is called refining & the Melasses thus expelled are commonly called Treacle.

The sugar is dissolved in lime water, and pumped into a boiler, where it is boiled, together with bullocks blood or whites of Eggs. This spice as it is called, that first is used entirely since the liquor has the property of becoming concrete as the temperature advances, & rises in the form of a scum carrying with it all the impurities, and rendering the liquor more clear & transparent. It is then pumped into reservoirs, & again put in small quantities into the pans where it is boiled to a certain consistence. It is then cooled and poured into moulds of a conical form, where by a confused crystallization it forms sugar loaf. These moulds have a hole at the bottom wch is at first stopped. Water is poured in small quantities wch has no effect upon the sugar but is sufficient to carry off the melasses, when the hole being opened, into the vessel underneath. Dish Clay is put at the top in a very moist state and the sugar attracts this moisture just as it wants it both for cleaning itself from melasses & for crystallization. The Melasses or the impurity of wch it is now cleared is boiled again & yields sugar, & what still remains is formed into the very coarsest kind of Sugar, which is ground. The sugarloaves thus

boiler

cone

formd are kept warm and are filled in heated rooms. The sugar is perhaps exposed in heated rooms, where by gradual crystallization it forms sugarcandy.

From the melasses, extracted in the very first operation, by fermentation & distillation an ardent spirit is obtained called Rum

Arts relative to Cloathing –

Flax, Hemp, Wool, Cotton, Silk all spun and are all wove they may therefore be included under one head

Flax is a vegetable wh grows in considerable abundance in this kingdom, however we are not able to supply ourselves. Great quantities of flax are imported from Russia – Livonia Riga – Government have fixd a premium for the raising of the greatest quantity of flax & hemp, wh may be claimed in the county. Hemp is also a vegetable, & is male & female. The male hemp soon comes to its perfection, and is weeded out by the roots; & sometime afterwards the female plant arrives at perfection, & is treated in the same manner. They are both laid in the open air till the vegetable parts are almost rotted. It is then beaten, by wh operation the hard woody parts are broken, & the head wh is the spinnable part of the hemp remains in fibres. It is then drawn thro' a comb Flax is then drawn up is put into water till it is in a state of fermentation. It is then spread to dry & rot. It passes thro' the several operations of beating, combing & spinning as well as Hemp. They

are both made into linen. The proper signification of the word Linen is cloth made from flax, as Linus means flax only.

Cotton is a vegetable growing in the East and west Indies. It is produced in a pod upon a tree. In due time the pods burst. The cotton is then picked & imported hither. It is beaten carded & spun. It may be spun to an amazing degree of fineness. 1 lb. is spun in 250 hanks. The finest cotton comes from the East Indies.

It is beaten upon a plate.

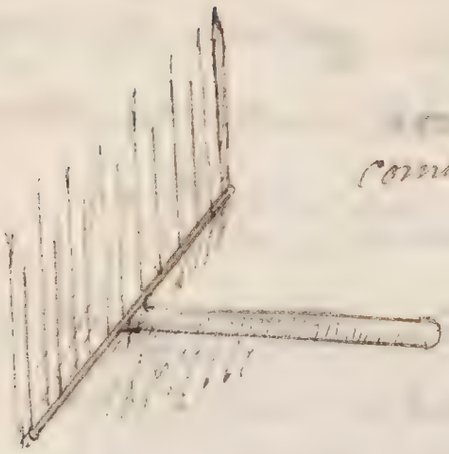
Wool is animal production. There are two sorts of it the long & short, produced on different kinds of sheep. Lincolnshire sheep produce the long wool. The finest wool grown in England is found in Sussex. There is however a much finer sort imported from Spain. The manufacture of the long & coarse wool, & the short or fine wool are entirely different. Short wool is made into cloth for coats &c. the long wool spun into worsted—

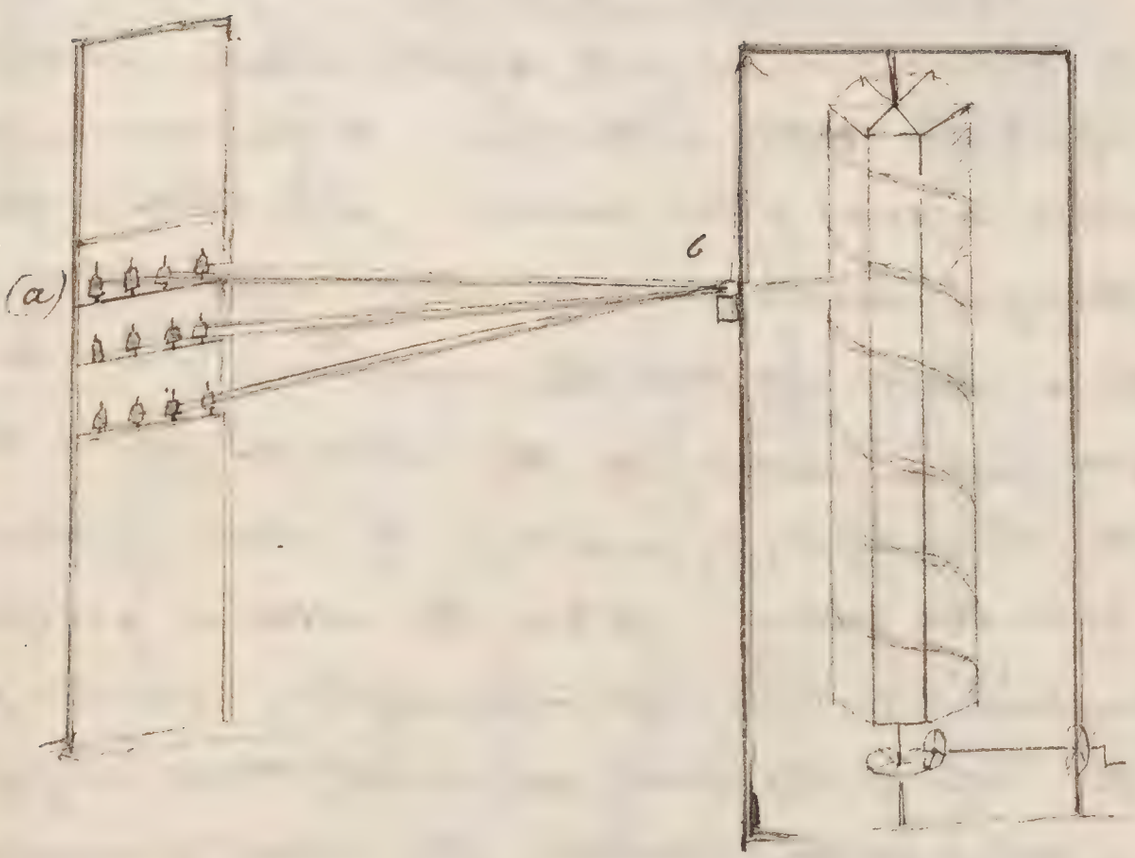
The short wool is treated like cotton & is spun by machines. The long wool is spun by hand, after having been combed. The sheep are washed and sheered at Midsummer.

The short wool is first washed well with soap and water, carded, scribbled, spun on a wheel, woven

beat in a pulling wheel — dried, dressed

The long wool manufactory must be first treated of. Having been well washed & beaten it is combed. It is drawn into slivers. The comb is heated in the fire to make it give back the wool well. The wool is drawn thro' several times till it lies in a state fit for drawing out into slivers as it is called. The comb is fixd firm & the workman draws the wool by hand into a very long broad thread called a sliver. ~~[illegible]~~ wrapped up [illegible] What remains on the comb is called Noyle and is manufactured into blankets. It is then spun. This was formerly done by this simple Instrument — & it is still used in Norfolk. the thread is fastened in a nick at the ~~bottom~~ top & the spindle is turned by rubbing it against the thigh & letting it swing. They can spin very fine threads with this but as it is a slow method of working wheels & mills are generally used. It is spun in warf & woof — warf is the strongest & is that that goes along the loom whereas the woof wh. crosses the loom needs but be weak. It wound on bobbins — and from off these it is wound round a machine & the threads which have been dyed are intermixed. The bobbins (a) each turn upon an axis very easily & the threads being conducted thro the passage (b) (at wh. there is a weight) reach the machine on wh. they are rolled. They are rolled round it in serpentine folds & always fall upon exactly the same place, owing to the weight (b) wh. rises & falls with them




(a)
b

~~beaten in a pulling wheel; dryd dressed~~

~~The long wool~~

It is then woven, the threads having been disposed upon the loom. Weaving is effected by crossing the threads & passing the shuttle between them this not sufficiently explained. Made into stuffs &c

Cotton & Short wool going thro' pretty nearly the same processes may be both included in one head

They are first beaten on a plate.

They are then spread upon a cloth and put into the scribbling machine. The cotton is spread lightly upon the cloth (a) wh passing between two rollers at (b) is drawn forward to the large wheel (c) which being turned by steam takes off the cotton that is spread upon the cloth. These two rollers are turned by the axis of the great wheel wh has a tooth wheel at the surface this acting upon a screw communicates motion to another tooth wheel. This last wheel has an axis communicating with a tooth wheel which turns the wheel of wh the roller is the axis. In this manner do these rollers acquire their motion. The cloth is then drawn through another pair of rollers at the bottom (e) and ~~is~~ thus passes off from the machine. These last rollers are put in motion by the wheel (d), which communicates with the wheel (f) & so to (g) by straps & the last wheel (g) turns the rollers. When the cotton is got upon the great wheel it begins to be scribbled. For this purpose at the top of the wheel are small fine combs (vid fig a) wh may be taken off at pleasure. The wheel turning & these combs remaining fixd, the cotton is finely carded or as it is called in this first operation scribbled. It is taken off the great wheel by another cylinder (h) wh is called the stripping wheel. This wheel has its surface covered with fine

plate

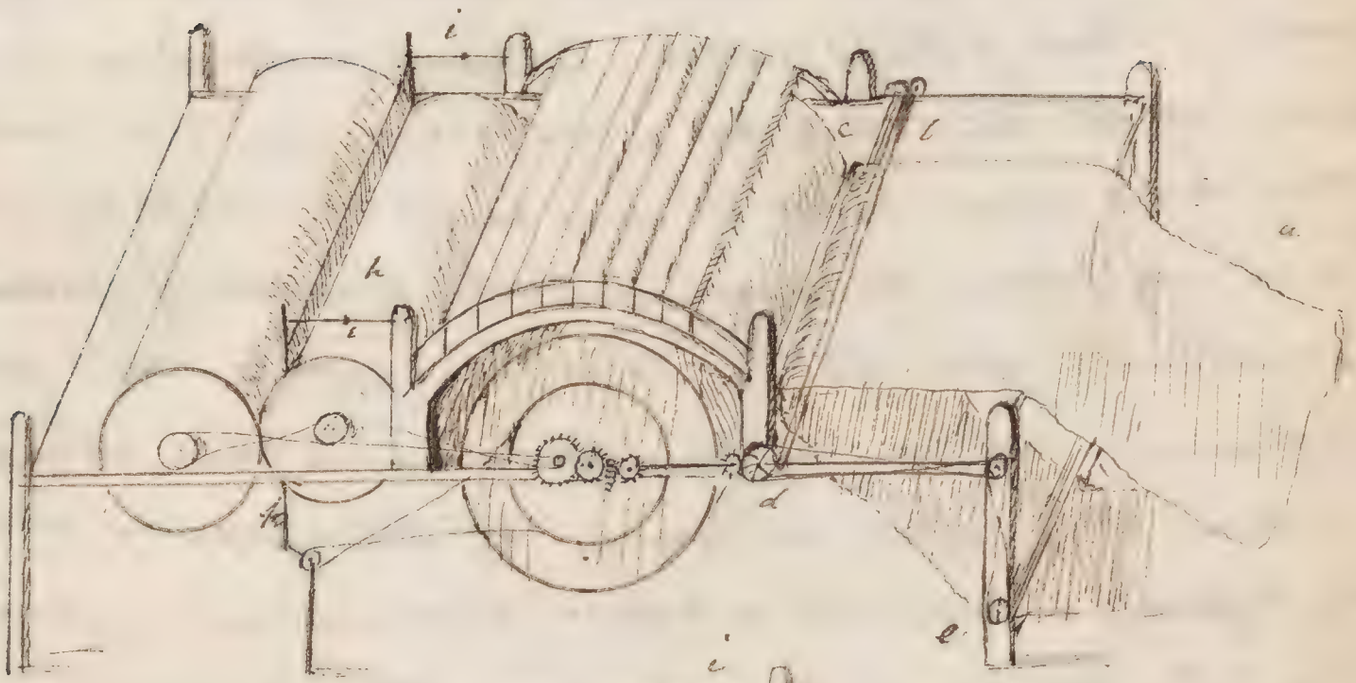
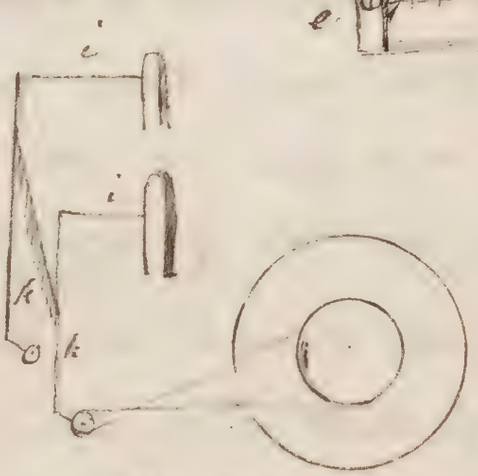
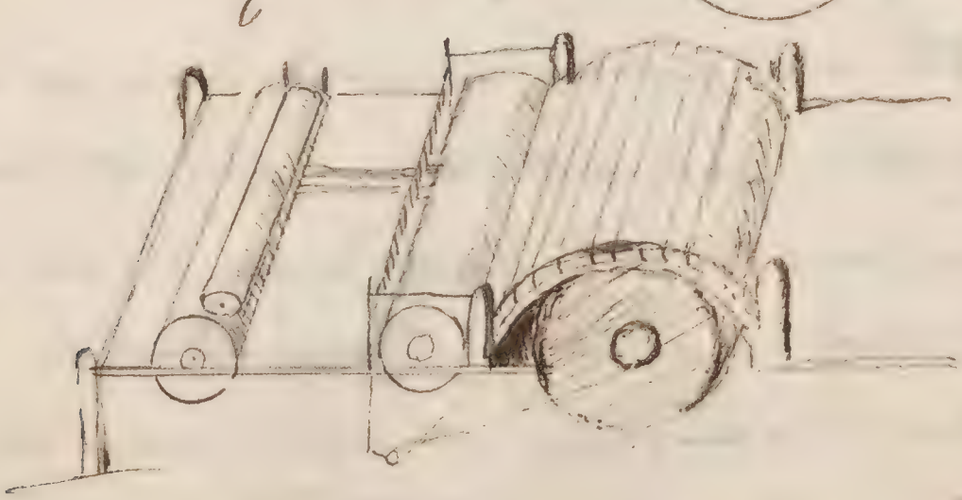


fig a.

B

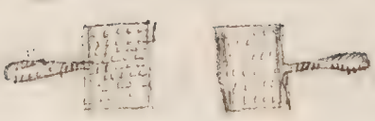


C



wire, so that ~~on~~ contact with the great cylinder it strips it of the cotton. But the most curious part of the machine yet remains. As the cotton accumulates on the stripping wheel it becomes necessary to take it off. For this purpose there are two small beams (i), with wh. the perpendiculars (k) are connected, vid also fig B. at each end of the stripping wheel. Now these perpendiculars receive a motion up & down from a small wheel wh. is turned by straps by the great cylinder as may be seen. These perpendiculars are connected with one another by a comb, wh. has consequently the same motion & thus combs off the cotton from the stripping wheel & lays it upon the drum (l). round wh. it is wound. Each of the cylinders, in drum & stripping wheel are turned by the large cylinder as may be seen. The cotton is then rolled upon a cloth wh. may now be done with the greatest ease by rolling the drum, and the operation of ~~carding~~ is scribbling is finished. It is then carded — the only difference between the two operations is this that in carding the cotton on coming off the stripping wheel by passing between two cylinders is drawn into a fine thread (Fig C). The drum being removed the two cylinders are placed in its room — one of these being larger than the other the thread is lengthened. The operation of scribbling was formerly done by hand — two small instruments of the form were used with teeth as combs ——————

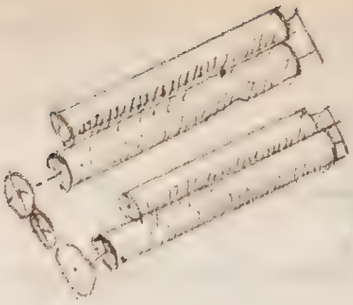
The next operation is in order to give the thread a twist to lengthen and at the same time to strengthen it. For this purpose the thread when carded is put loose into baskets one hank in each basket. They are then put to a machine wh. twists two or three of them together and makes the thread thus formed of a considerable length.

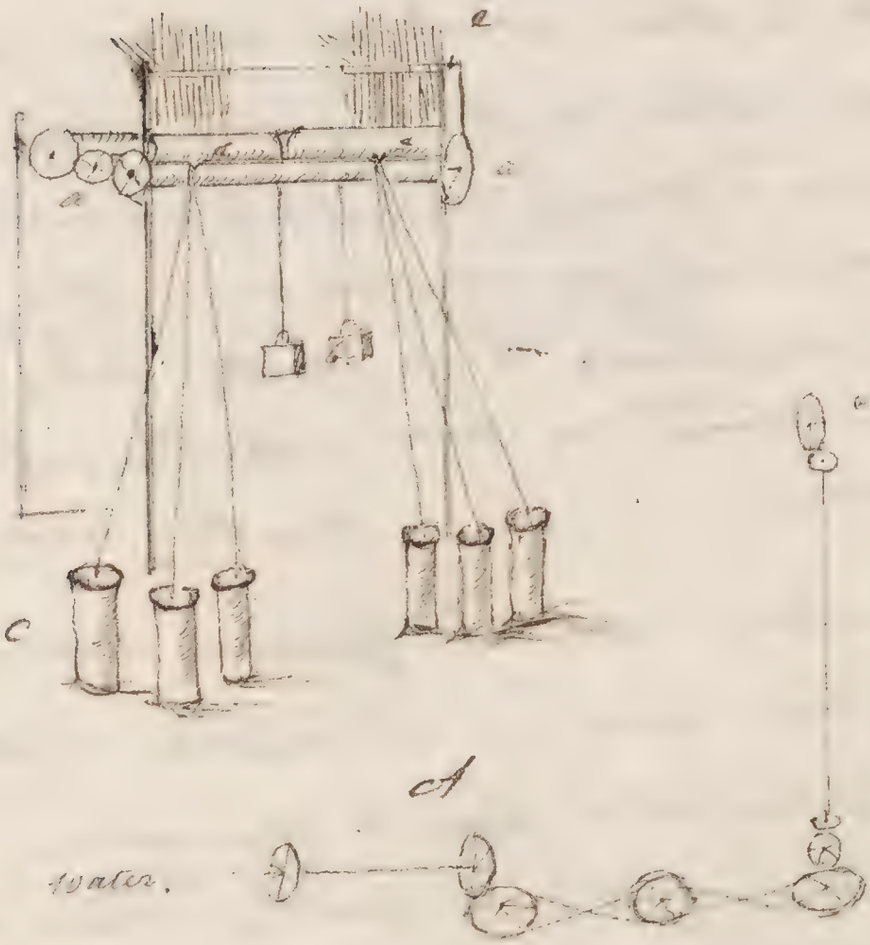


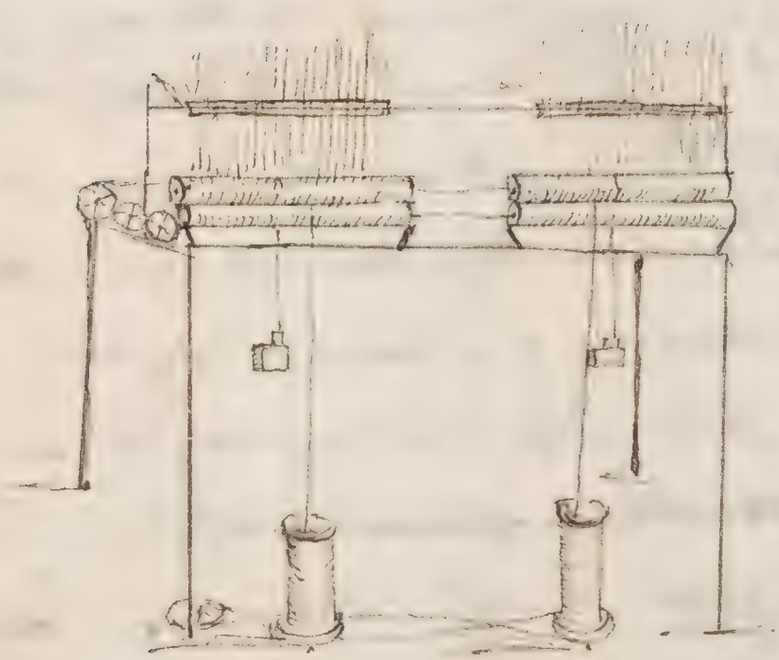
The grand principle upon wh. these machines are formed is this that if there are four rollers or two sets of rollers wh. are turnd the same ~~different~~ ways but are of unequal sizes the larger set will pull the thread more than the less. To make them turn the same way a wheel is introduced between them. On this principle the mule is constructed.

The machine for drawing thread is as this. There are two sets of rollers as above wh. are turnd by the wheel (a). The under rollers only are turnd the upper ones being turnd by them. The upper rollers are covered with leather & are kept down tight by heavy weights (b). The thread wh. has been carded is put into the baskets (c) & is conveyd between the rollers thro' the aperture (d) it is then drawn thro' the other pair of rollers wh. are much the largest & the several threads are then united in one and are by this produced to a very considerable extent. Above there are two brush wheels (e) wh. touch the leathern rollers & serve to clean them of little pieces of cotton wh. would otherwise stick there. They are turnd by the wheel (a) & the whole machine is turnd by water & a succession of wheels (f) (g) (h). The thread is received in cannisters as it comes out on the other side.

The next operation is giving the thread a small twist. This is effected by making the cannister in wh. it is received, having past the rollers, turn about. This is done by connecting them with the wheels that turn the machine. This represents the back part of the machine.



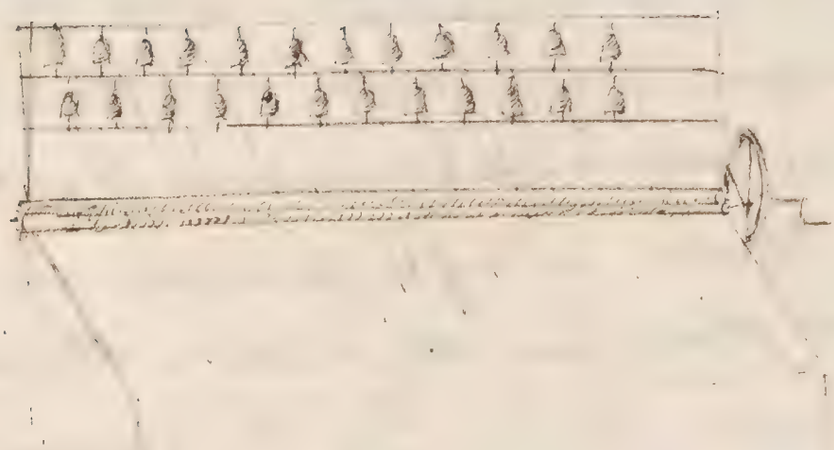

e
a
c
d
water.

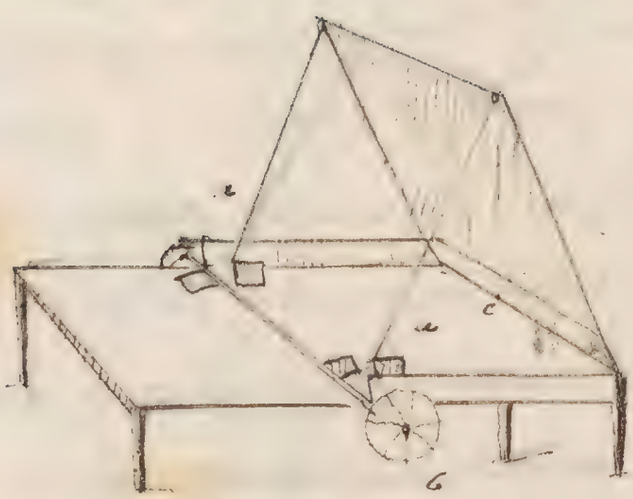


The construction of the cannister in the twisting mill is something curious - There are two rollers over the mouth of the cannister which are turned by a wheel which is turned also by the wheel which moves the exploder cannister - so that the thread is passed thro' these rollers (by the turning of the cannister) into slightly twisted.

The cotton is then wound on bobbins and put in a machine called a Mule wherein it is spun to the greater degree of fineness that is well adapted for. This spun in the machine for muslins &c - The machine is much too complicated to be properly taken on paper - The bobbin turn'd on pins & the threads are conveyed between rollers ——— It is then wove —

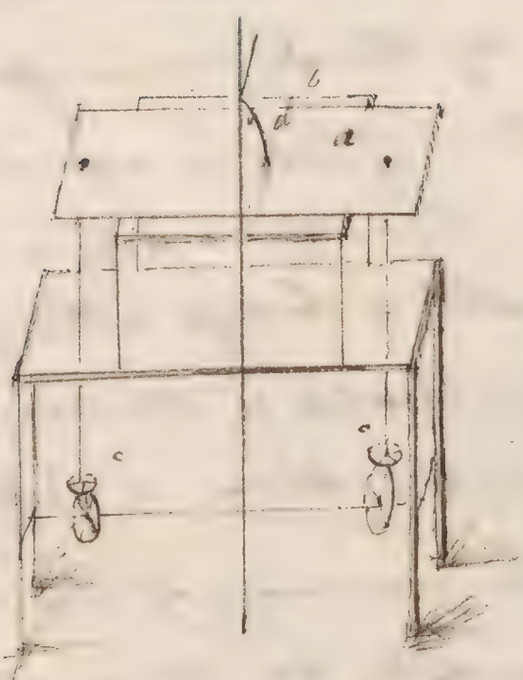
The wool undergoes all these operations except that of the mule. Having been wove it is milled & cleaned — For this purpose it is put in a machine of this form set in motion by a water mill. There are materials for cleaning the cloth in the mill such as water soap &c — The two hammers (a) are moved by the cogs upon the axis of the wheel (b) and beat alternately the cloth with lies in c. The water being beat into it the cloth is quite cleaned. By this operation the cloth grows firmer & closer & whereas before all the threads might be plainly distinguished as in a piece of linen, upon this operation there is now a thick nap upon the cloth. The cloth loses considerably in length by milling - in order in some measure to restore it, it is put upon tenters & stretched very much. However after all it never recovers its former size ——— In order to make the cloth diminish in




a
c
b

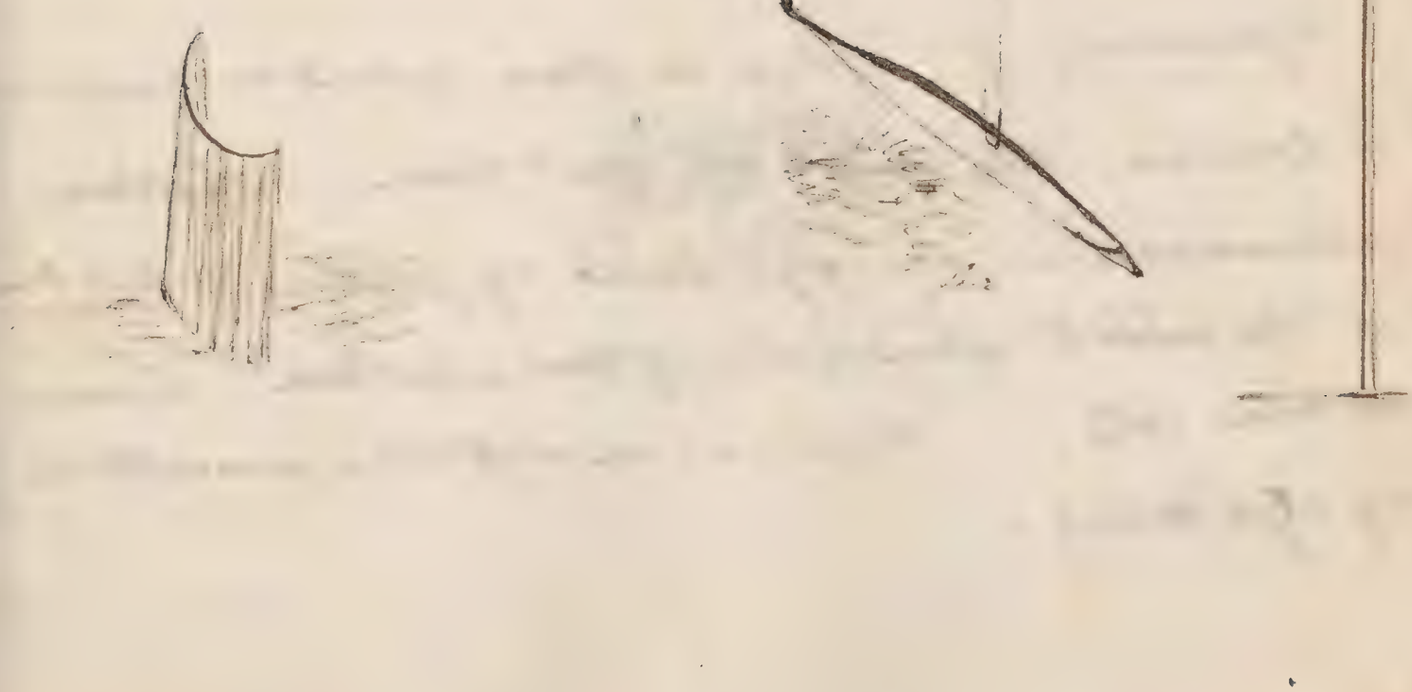
breadth & not in length they twist the cloth before they put it into the tilting mill. It would grow into a solid mass owing to the adhesion of the nap if they were not to take it out continually & untwist it.
as the nap is of very unequal length it undergoes several processes before it arrives at the state in wh. we see it. It is rubbed with a teazle with a design to make all the nap rise up. This is a small hand instrument with teeth — something like a curry comb — When the nap is raised it is then sheard short. The shears are of a peculiar construction. One blade lies flat upon the cloth & the other has an oblique position to it. By this means the nap wh. comes between them is cut regularly. The cloth ~~cut~~ passd over twice with the shears. It is then hot pressed to give it a gloss. ~~Between each~~ Upon every surface is laid a piece of paper. It is then packd up in bales ~~with~~ by a press. There are some sorts of cloth such as Womens cloaks are made of wh. have the nap raised in small lumps this is effected by an operation called prizing. vid fig. The board (a) ~~has teeth on the underside~~ it is laid upon a table (b) & the cloth put between them. The board is then put into motion by means the two wheels (c) wh. also receive their motion by wheels connected with a steam engine. These wheels give the board a sort of circular motion, by wh. means the naps is combd into little round lumps. The board is pressd close by a spring (d) This operation is called prizing. Pitch & sharp sand are put over the cloth & the board wh. is now is heated, by wh. means the pitch melts & draws the nap

a plant called nagle



This disposition of wool to give a nap is a very curious circumstance, as neither silk, flax, nor cotton have it. It may be accounted for in this manner. If a hair be rubbed between the finger & thumb it will be found always to travel on towards the roots. Now this shows that there is a scale upon hair, & this scale forms sharp angles will connect one hair with another. So that when cloth comes to be milled the hairs being very much intimately connected & tangled with one another form the nap, & contract the cloth. This is a very valuable property in wool as by means of it wool may be felted i.e. stuck together without weaving. Hats are made in this way.

Hats are made of all sort of wool - generally of rabbit wool. The upper surface of fine hats is made of Beaver fur. The Beaver skins are imported from North America and sometimes in the form they have been cut into by the Indians for cloathing they then called old coats. There is a great deal of long hair grows on the Beaver wh is of no use at all in Hatting. This is pulled off with a knife & the fine fur left. Rabbit skins are treated in the same way. This fine fur is taken off the skins & is pulled out with a bow string. The meaning of this is that the fur by being struck quickly by a bow string flies each hair being separated great
and lies extremely light, a basket is set to prevent it going too far. It lies thus light & is rubbed by leather cloths laid over it for some time till the different hairs wh were spread by the pulling out

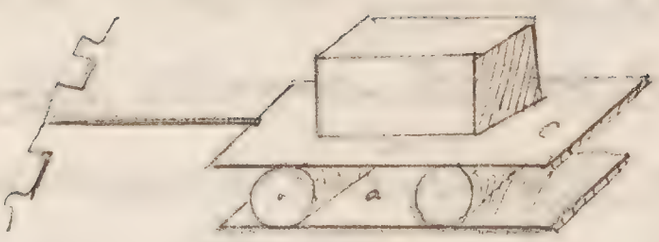


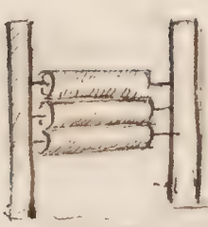
yet intangled & intimately connected with one another so that the whole is matted together. It is then put into warm water & afterwards rolled. This is repeated — It is then put into water & oil of vitriol wh. makes it shrink very much. It is made in the form of a cone. whilst wet the cone is doubled in — & what is intended for the rim of the hat is stretched by hand. It is then put on a block. and the crown is formed. — It is then dyed.

Cotton &c continued — Cotton is calendered — this method was very general but Hot pressing has superseded it very much. The cotton is put upon the two rollers (a) and the great weight (b) wh. presses upon them is drawn backwards & forwards with the board (c) This gives cottons a glaze —

It is necessary that the heavy fibres of cottons sh. be burnt as they very much impede the dying. These fibres burn very soon.

Cylindering — There are three cylinders press'd close by together; the middle one of wh. turns. Shalloons callimancoes &c are cylindered by putting a hot Iron in the middle cylinder wh. is of Iron & hollow. Linens are done cold. Linens &c are stiffened & smoothened by cylindering.


a



Printing Linens Cottons &c —

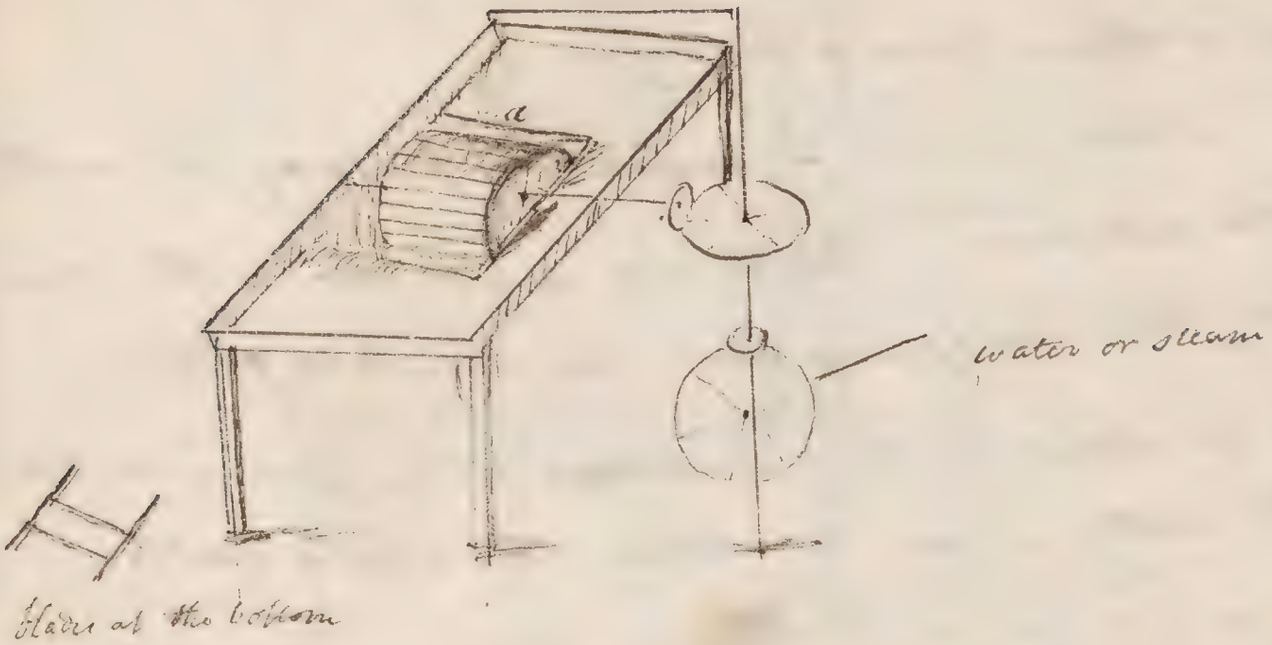
Linens are printed by blocks wh have the figure upon them, & each of wh bears a different colour. The first Block is dipped in the Iron liquor, a composition of Iron & vegetable acid made into a paste & diluted. This scarcely tinges the linen. The next block is that wh is perhaps to give the red colour to some parts, wh only are therefore marked upon the block. The next to give the blue & this block contains only that part of the fig. to be painted blue & Iron, Iron is the basis of most of the colours. Iron liquor is the basis of black. Iron liquor diluted gives a red. Alum mixed with paste gives a deep red. These are all Mordants or colours wh dont appear till dipped into some (other colour) fluid. When all the Impressions have been taken off the linen is dipped into (boiling) Madder & water & left held in for a little time. on it coming out all the colours appear. The white (when well bleached) parts have only a slight tinge of red, but this comes out by bleaching. In bleaching great care must be taken that no calcareous earth get upon the linen as it would prevent the dying. Linen is washed in an alkaline ley & exposed to the air, in bleaching. To get rid of calcareous earths, dephlogisticated or oxygenated muriatic acid is applied to it.

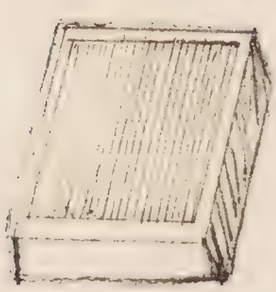
Silk –

Is an animal ~~production~~ substance, the production of a worm calld the Silk-worm. The manner of its production is well known – Some of the balls are white & some yellow the white ones are esteemed the best. The worms that are designd to be destroyd, are killd whilst in the balls by putting them in an oven. The Crysalis eating its way thro' the balls appears in the form of a ~~butter~~ moth & lays its eggs. These eggs are hatched in France by the women who carry them about their bodies that the heat may bring the worms to life. This Climate is not favorable to these worms as they are extremely sensible of cold. The mulberry leaf is their food. Of this tree there are two kinds the black & white. The black is a very slow growing tree, the white a very quick one, but it will not bear our climate. It is the last of these trees that afford provision to the silkworms in Italy & France. In order to cleanse the worms they put fine nets & mulb. leaves over them & the worm creeps thro' to them. They cast their skins every 4 days. Warmth is very beneficial to them. They arrive at perfection in abt. 6 weeks – they then begin to spin &c – The balls or cockoons are cleaned of all dirt by taking off a little of the outside silk. They are then put in water & freed from the gum by soap. They are then thrown & wound three or four threads are formd into one – silk is spun &c a. cotton –

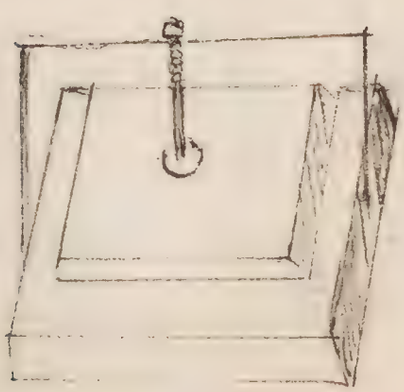
Paper.

Is made of linen rags cut & ground into a size. The Rags are first well washd in the trough in wh they are cut, the wheel being a little raisd to prevent their being cut. The great wheel (a) has blades upon it wh fitting two blades at the bottom of the trough cut all the rags that come between into small pieces. Now this wheel, being a little raisd from the blades at the bottom & the trough filld with fair water it drives the rags about with great force & there being a little declivity in one part of the trough the water has a circulatory motion flows round — the first dirty water being drawn off clean is poured on till the rags ~~become~~ are quite cleansed. The wheel (a) is then let down and water being put in with the rags, & the wheel turnd by a succession of wheels (wh receive their first motion from a water wheel or steam engine) the rags are in time reduced to very fine powder wh mixing with the water forms a size. It is then drawn off into a caldron & made milk warm. The mould is then dippd in and immediately taken out again. There is a frame round the grate in the mould, so that the grate ~~will~~ may be taken out when requisite. The water having run off thro' the grate, the sediments remains at the top, the grate is taken out & this sedt deposited on flannel. The sheet is then pressd & deprived of all its water. Being immediately taken out it is agn laid between flannels. It is then sized. This size



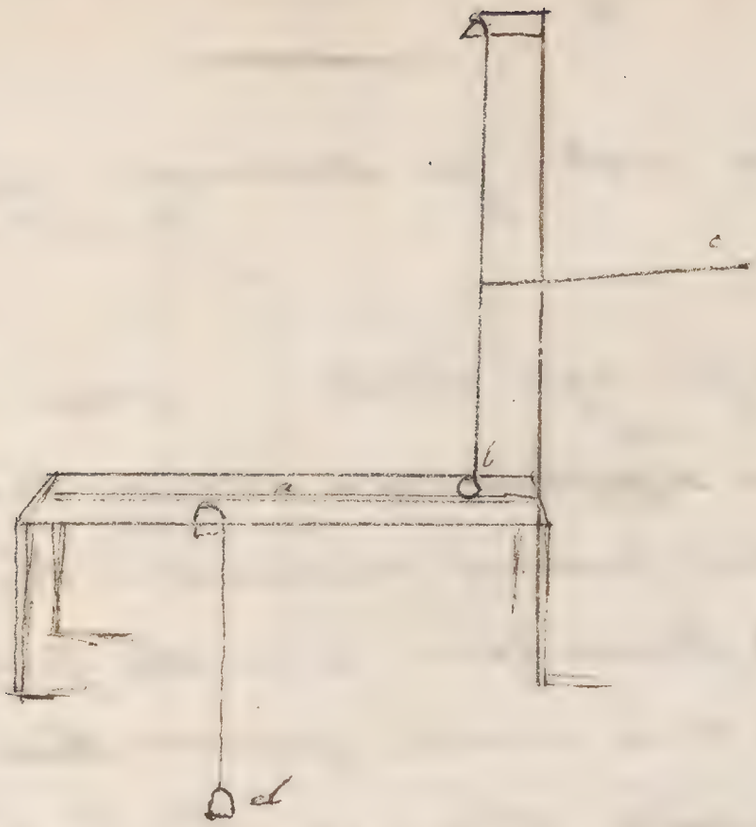


Mould



is made of bold leather & is a very weak glue. The use of this is to prevt the ink's running. — The sheet is then hung to dry.

Strong paper is made by pressing two or three sheets into one. Cards are made ~~the~~ in the same way. It is necessary that they should be glazed — This is done by this machine wh is just in motion by the water wheel wh turns the whole work (a) is an iron bar on wh the card is fixed (b) wh is fixd & does not move round runs over the card. The bar (c) being movd backwards & forwards by the wheel gives the same motion to the bar & wheel connected with it. In order that the card may lie true to the wheel the iron bar is kept up by a stirrup (d). The whole goes with great force.


a
b
c
d

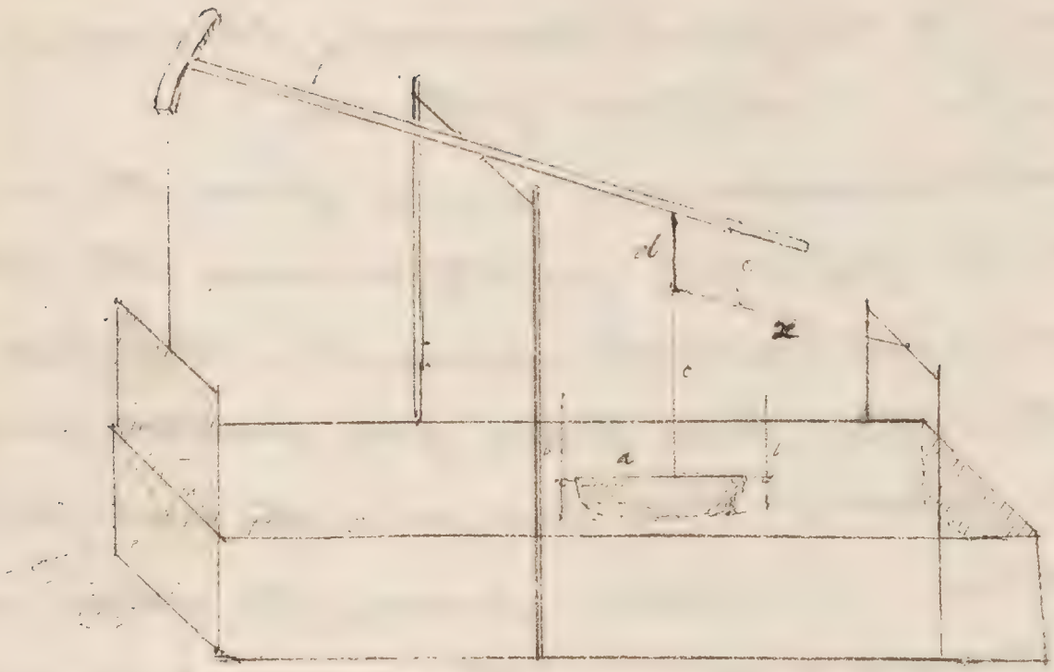
Navigable Rivers and Canals.

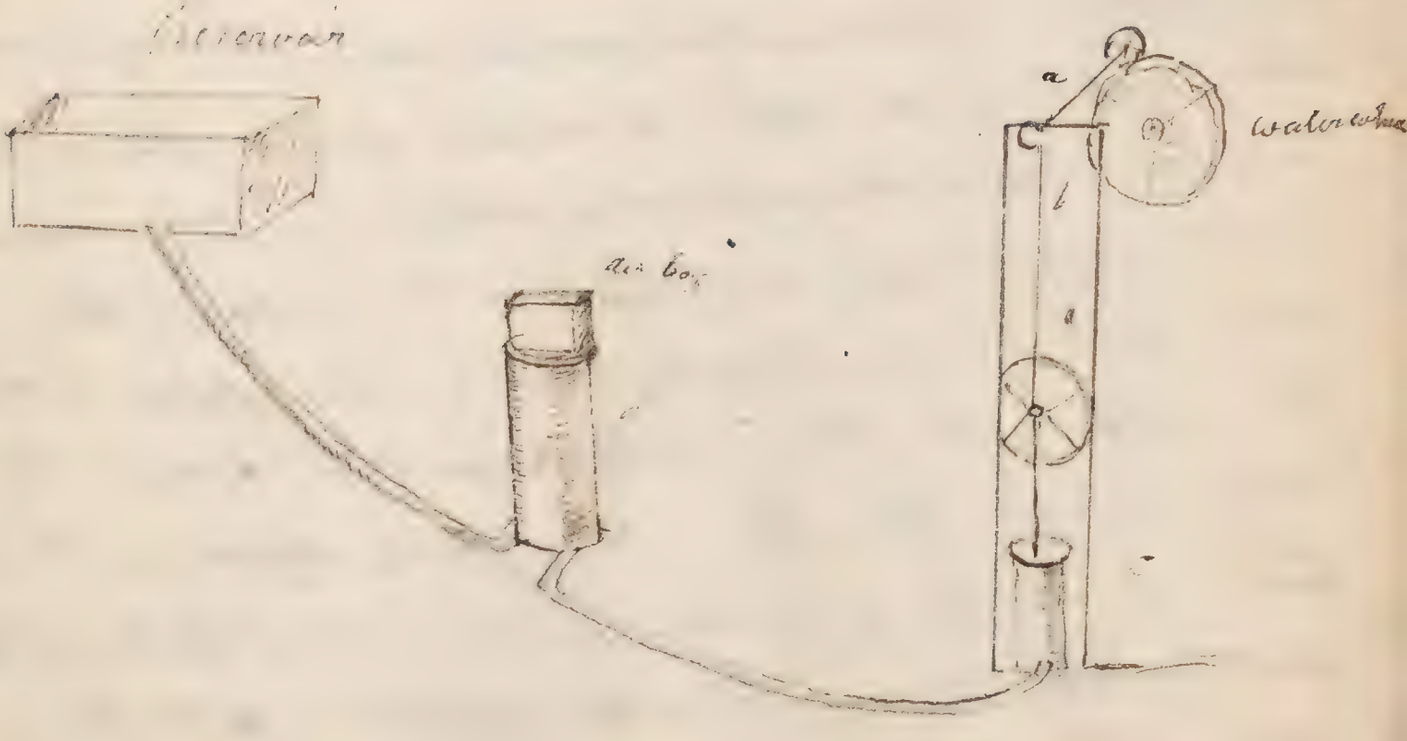
Canals are either for drainage, aqueducts, or Navigation.

Canals for aqueducts. New River one of these. It is supplied by a stream that runs near. However the persons concerned in the New River have obtained permission from the proprietors of the River Lea to take a certain quantity thence. To regulate this supply they use the Balance Engine. It is situated at the head of the new river The boat (a) is raised by the water which flows in & it rises upon two pins (b). The bar (c) being also raised raises (d) which rises by the moveable bar &c. This being raised depresses (e) & consequently depresses the other end of the lever (f) with which is connected a floodgate. This being depressed the water flowing into the River stops.

Water may be conveyed to a situation higher than the spot to be watered & conveyed thence by pipes.

The Waterworks at London Bridge are carried on in this manner. The axis (a) is turned by a water wheel & has at the end a crank communicating with the rod (b) of the pump. This Rod is fixed at the centre of a wheel running between two cheeks in order to keep the rod steady. Another rod then goes to the pump (c), & the whole is raised up & down by the crank & axis (a). The water is conveyed first a pipe to a cistern (d)


d
x
c
a

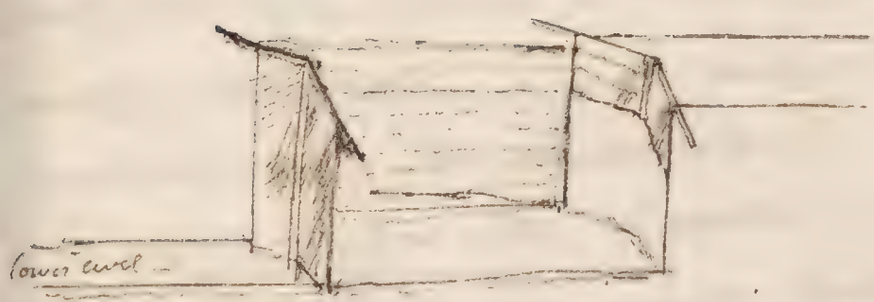

Reservoir
a
water wheel
b
d
air box

In the upper part of wh is a large inverted vessel. Now the water pressing into the cistern the elasticity ~~force~~ of the air will force it thro' another pipe to a considerable height to the grand reservoir. It is conveyed thence by pipes to all parts of the city.

A considerable inconvenience arises from the air's getting into the pipes, wh greatly increases the work of the pump & consequently diminishes the effect. To remedy this they have pipes going from the principal water pipes wh they open or in the water pipes they have valves, wh shutting prevent the water's going back to the pump & consequently any effect produced by the expansion of the air beyond them from being communicated to the machine.

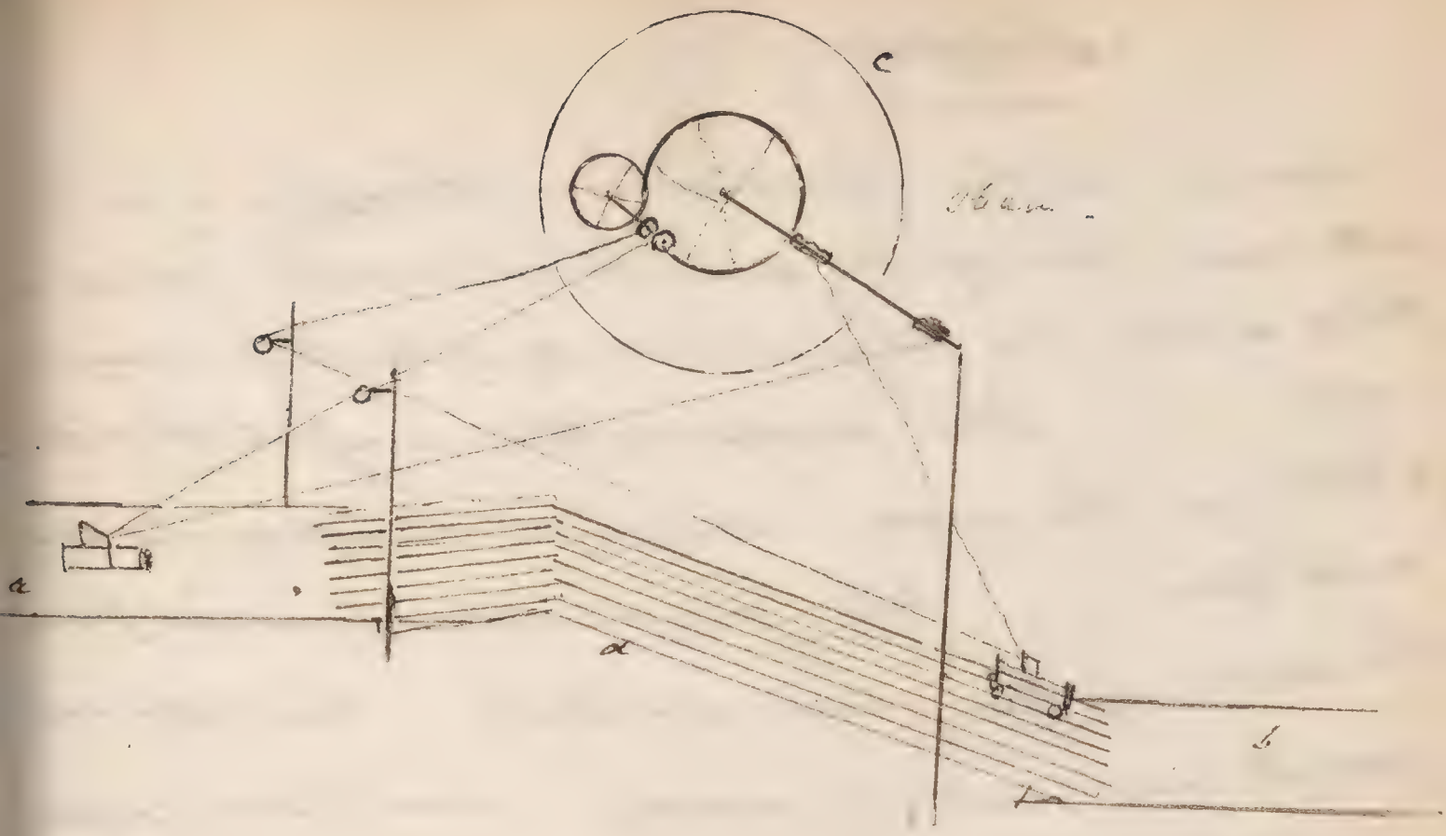
Canals for Navigation.

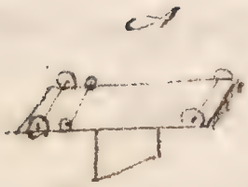
The difficulty chiefly lies in finding a proper level. Where a continued level cannot be obtained they have different contrivances for raising boats up to the higher levels. The most common one is that of locks. The gates in the lower level are opened, the boat sails into the lock & the gates close behind it. The sluices in the upper level are opened & the water in the lock rises to a level with that in the upper level the upper gates then easily ~~pass thro'~~ open & the boat passes through. The great defect in these locks is the loss of water, as each boat takes a lock full of water to raise it & this all falls into the lower level. Where there is plenty of water this is no object but it is a very great inconvenience in some countries.

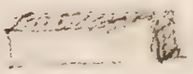

lower level

They raise boats by steam Engines up an inclined plane. (a) is the upper level (b) the lower.

The boat sails into a frame (fig 4) & is drawn by the steam engine (c) with proper ropes as may be seen in ye figure; up the inclined plane (d). The boats are drawn from the upper & lower levels at the same time. When they have arrived at the top, they would overset upon changing their position either in descending or ascending as the wheels wh. kept the boat ~~steady~~ even level in ascending would be so unequal that on the descent the boat would ~~[illegible]~~ be much lower before than behind. To prevent this there are 6 wheels to the frames, 4 of wh. keep the boat even in ascending and on the descent two larger wheels supplying the place of the first wheels the boat still continues even. It then runs down the plane & sails out of the frame. The waggon ways are unequal being suited to the different wheels. When the boat ascends the fore wheels are the least, but when it descends the waggon ways on wh. the 2d pair of wheels runs (wh. are ~~[illegible]~~ larger than the hind ones) are elevated above the others, considerably, & keep the boat level. When the boats are arrived at the top of the planes, the ropes are unhooked & others put on, & the steam engine is turned the other way round.


c
Beam.
a
d
b


A


Section.

Shipping.

Ships are sheathed sometimes with copper sometimes with wood. Large vessels generally with copper. The Wood sheathing is this one plank over the edge of the other to keep out water.

It is necessary that a vessel should be stable in the water; this depends upon its shape and load. The fluid acts upwards from the centre of the fluid displaced. The body acts towards our centre of gravity — when these concur the vessel will not oversch. If this position should be altered by any accident so as to endanger the oversetting of the vessel, the ship has stable & powerful righting itself. When the ship's centre of gravity is above the centre of motion it will not right itself, but when it coincides with or is below it, it will right itself. The heeling of vessels & their again righting depends on this. This roundness of the centre is called the metacentre.

In launching vessels they are raid from the slips on wh they are built by wedges. The shores or side supporters are knocked away & the ship goes in head foremost.

owing to mismanagement of his time the Lecturer was
obliged to omit all the other subject contained in his syllabus

Putty is the calx of tin ~~and earth~~

Soap is a mixture of caustic alkali (i.e. fixed alkali deprived of its fixed air by lime) and oil —